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Staerzl

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[45] Date of Patent: Jan. 12, 1999

[54] **LOW EMISSION TWO CYCLE ENGINE USING TWO SEGMENT PISTON**

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[73] Assignee: **Brunswick Corporation**, Lake Forest, Ill.

[21] Appl. No.: **881,212**

[22] Filed: **Jun. 24, 1997**

[51] **Int. Cl.**[6] **F02B 33/14**

[52] **U.S. Cl.** .... **123/65 S**; 123/73 PP; 123/58.6

[58] **Field of Search** .... 123/73 PP, 65 S, 123/58.5, 58.6, 73 F, 47 A

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,452,011	4/1923	Watton	123/73 F
2,923,281	2/1960	De Martin	123/73 F
3,996,903	12/1976	Cseh	123/65 S
4,068,629	1/1978	Hopper	123/65 S
4,138,971	2/1979	Fujikawa	123/58.6
4,169,434	10/1979	Guenther	123/47 A
4,210,108	7/1980	Hooper	123/65 S
4,522,163	6/1985	Hooper	123/73 F
5,189,995	3/1993	Hooper	123/58.6
5,261,358	11/1993	Rorke	123/58.5

FOREIGN PATENT DOCUMENTS

1013920	8/1957	Germany	123/65 S
1495556	12/1977	United Kingdom	123/65 S

OTHER PUBLICATIONS

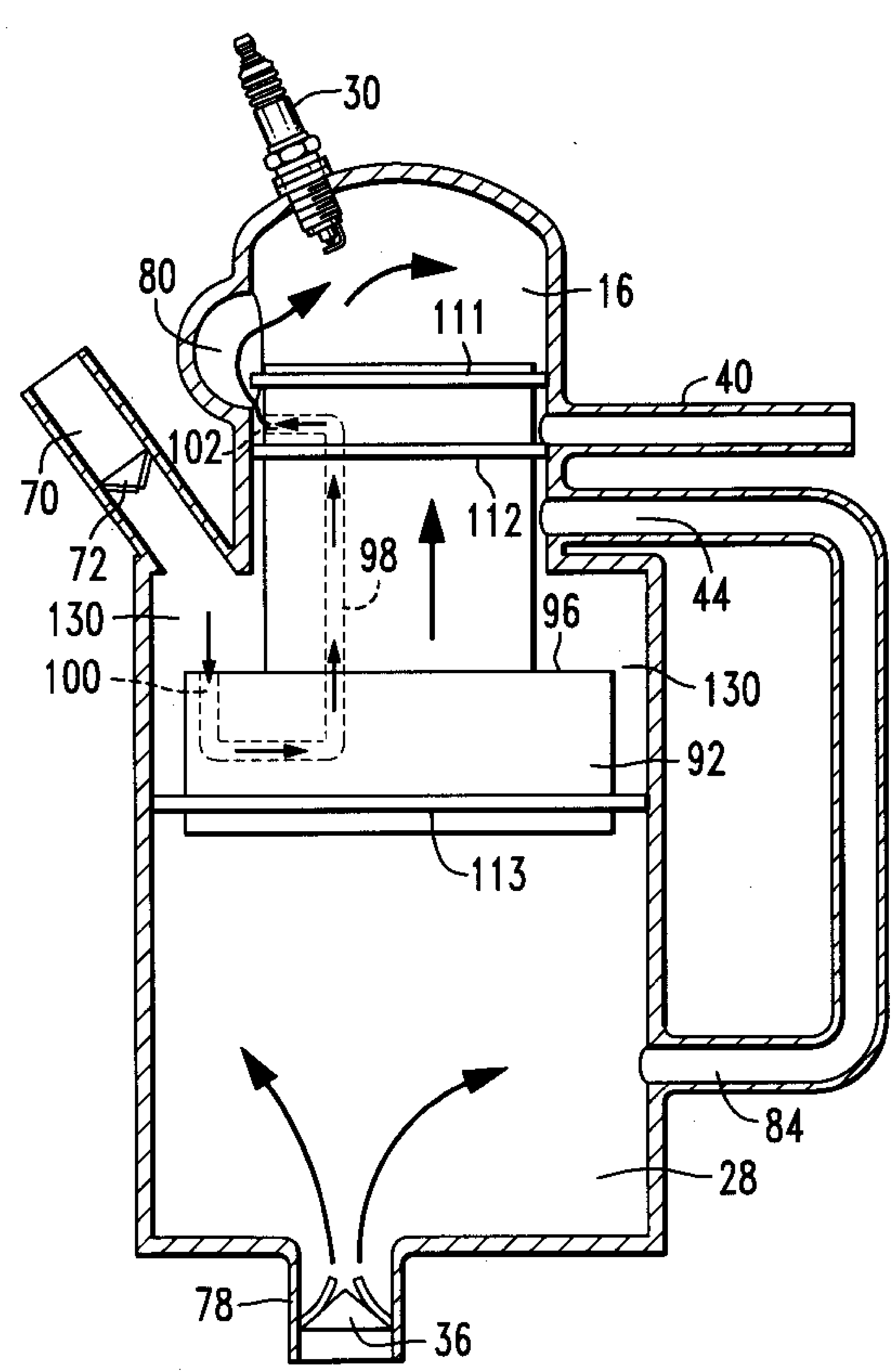
"Hooper's Hope" by Dave Searle and Doug Jackson, Oct. 1996, *Motorcycle Consumer News;* pp. 8–9.

Primary Examiner—David A. Okonsky
Attorney, Agent, or Firm—William D. Lanyi

[57] **ABSTRACT**

An internal combustion engine is provided with a top hat piston disposed in a cylinder having first and second portions of different diameters. The piston, with first and second portions of different diameters, is disposed within the cylinder and defines a compression chamber between a cylinder step and a piston step created by the different diameters. The compression chamber is connected in fluid communication with a fuel supply, such as a carburetor or fuel injector, which provides a fuel/air mixture into the compression chamber during the downstroke of the piston. When the piston is moving upward, it compresses the fuel/air mixture within the compression chamber until a second end of a transfer passage is moved into fluid communication with a transfer port formed in the wall of the first portion of the cylinder. This occurs after the exhaust port is closed by the piston and therefore significantly diminishes the chance for unburned fuel to pass directly out the exhaust port from the combustion chamber.

20 Claims, 9 Drawing Sheets



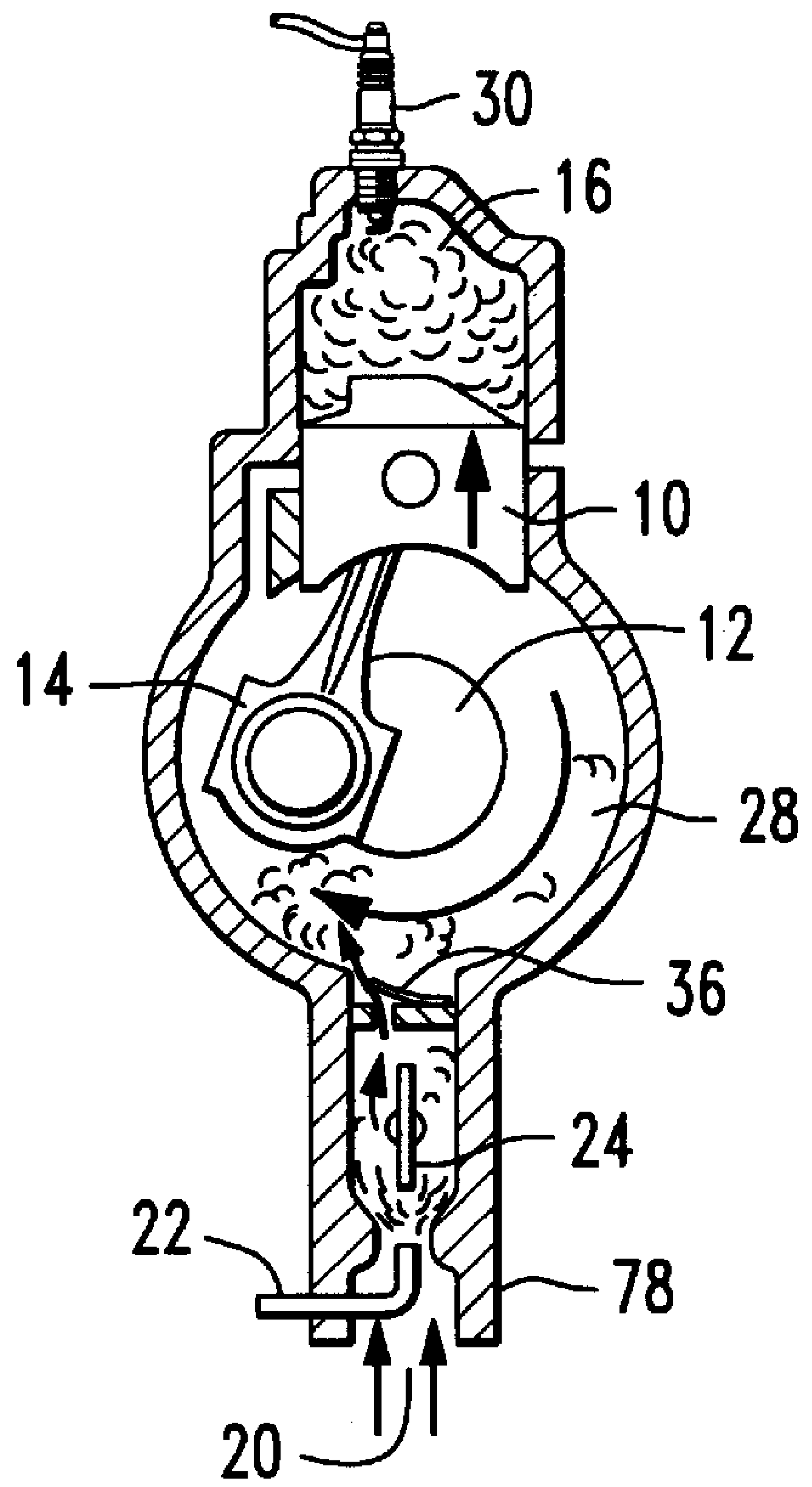


FIG. 1A
PRIOR ART

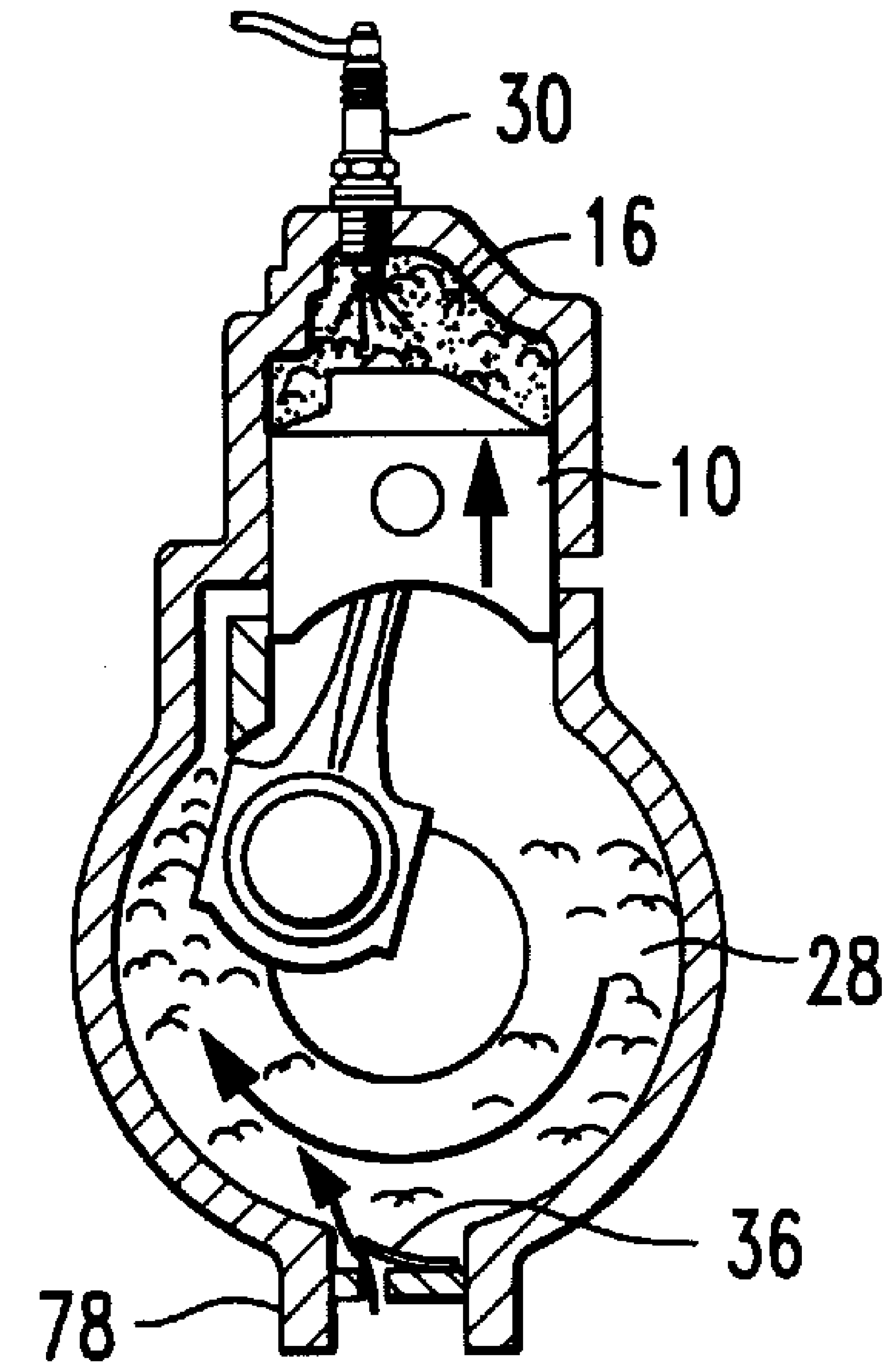


FIG. 1B
PRIOR ART

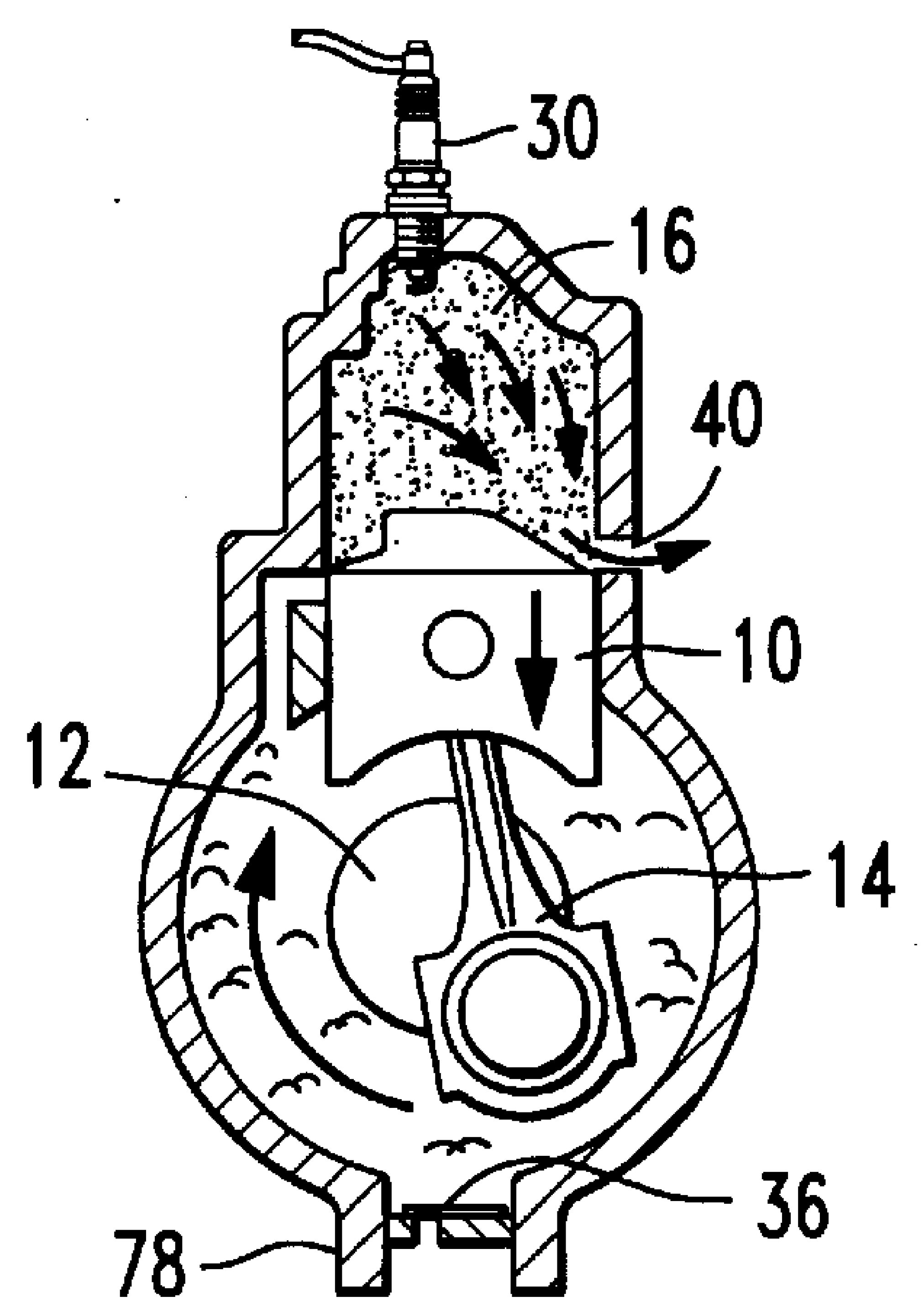


FIG. 1C
PRIOR ART

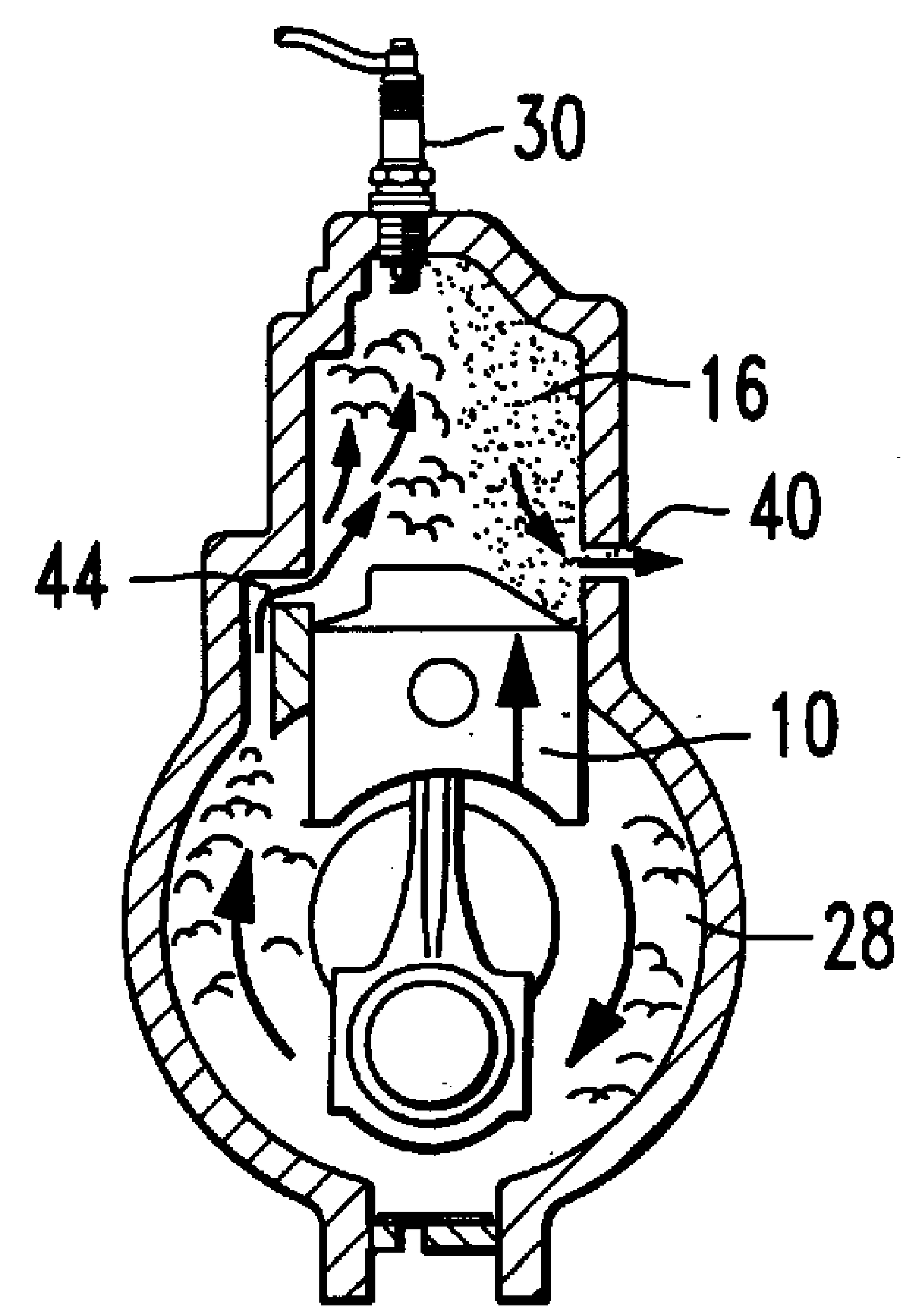


FIG. 1D
PRIOR ART

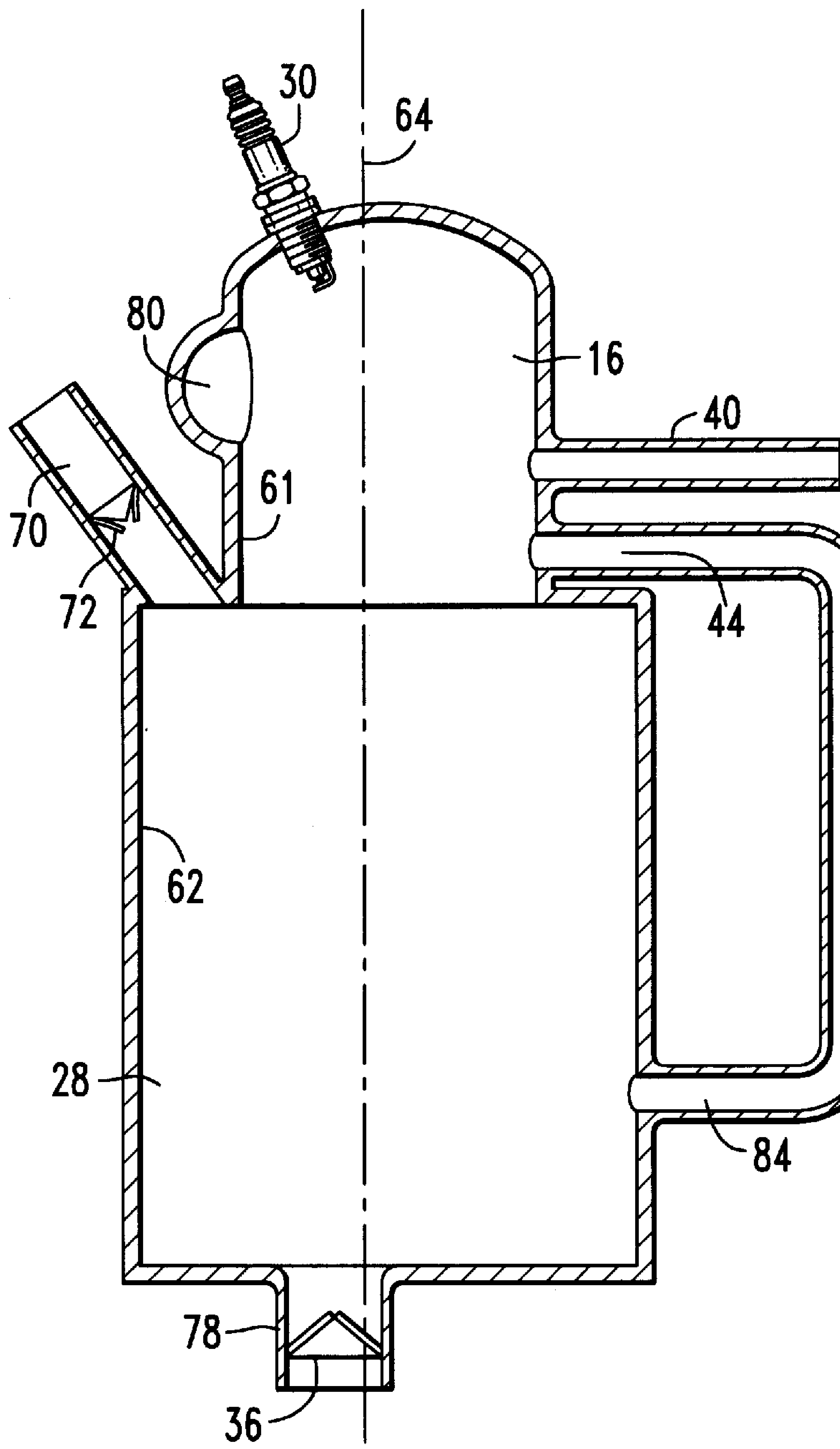


FIG. 2

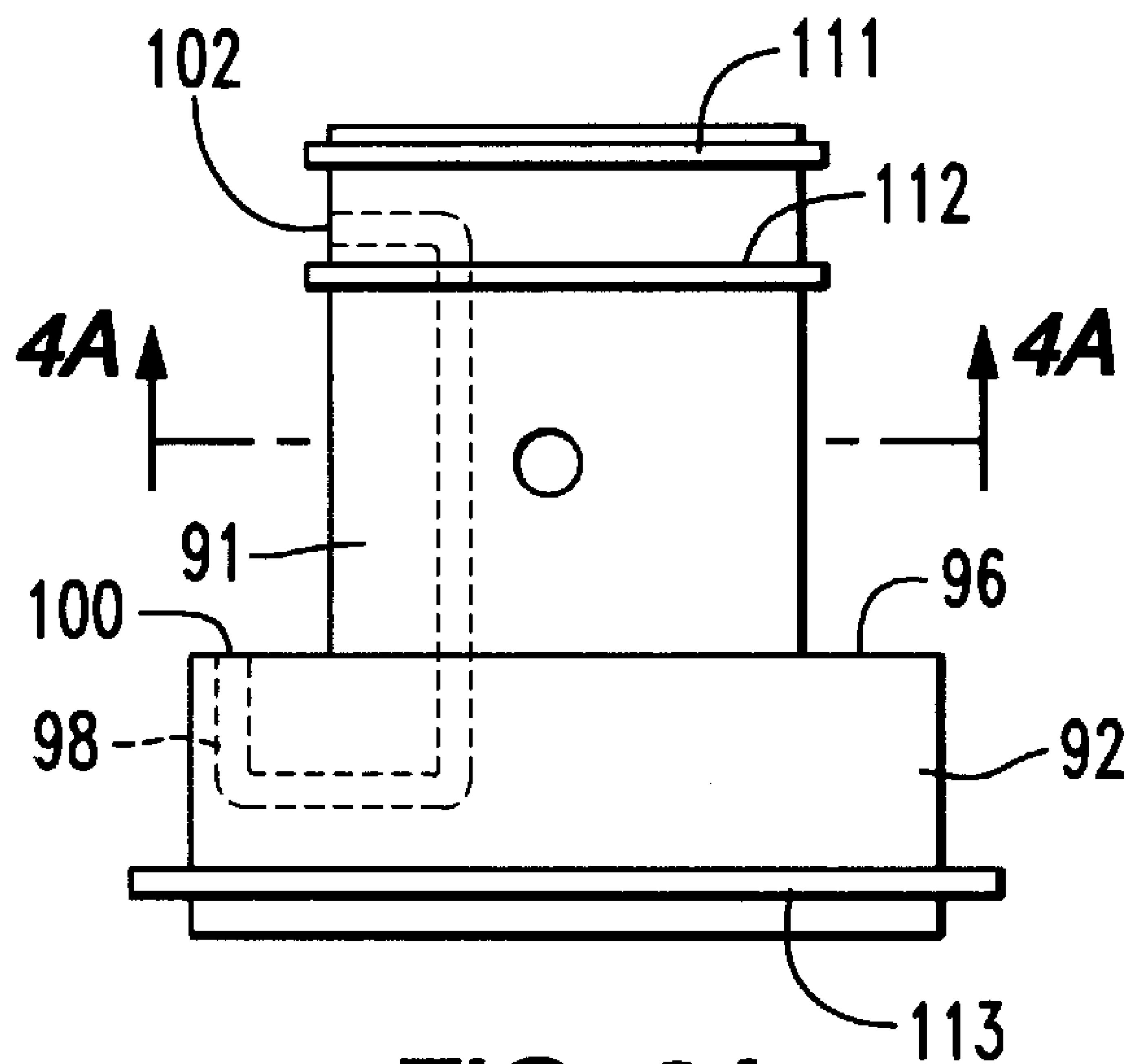


FIG. 3A

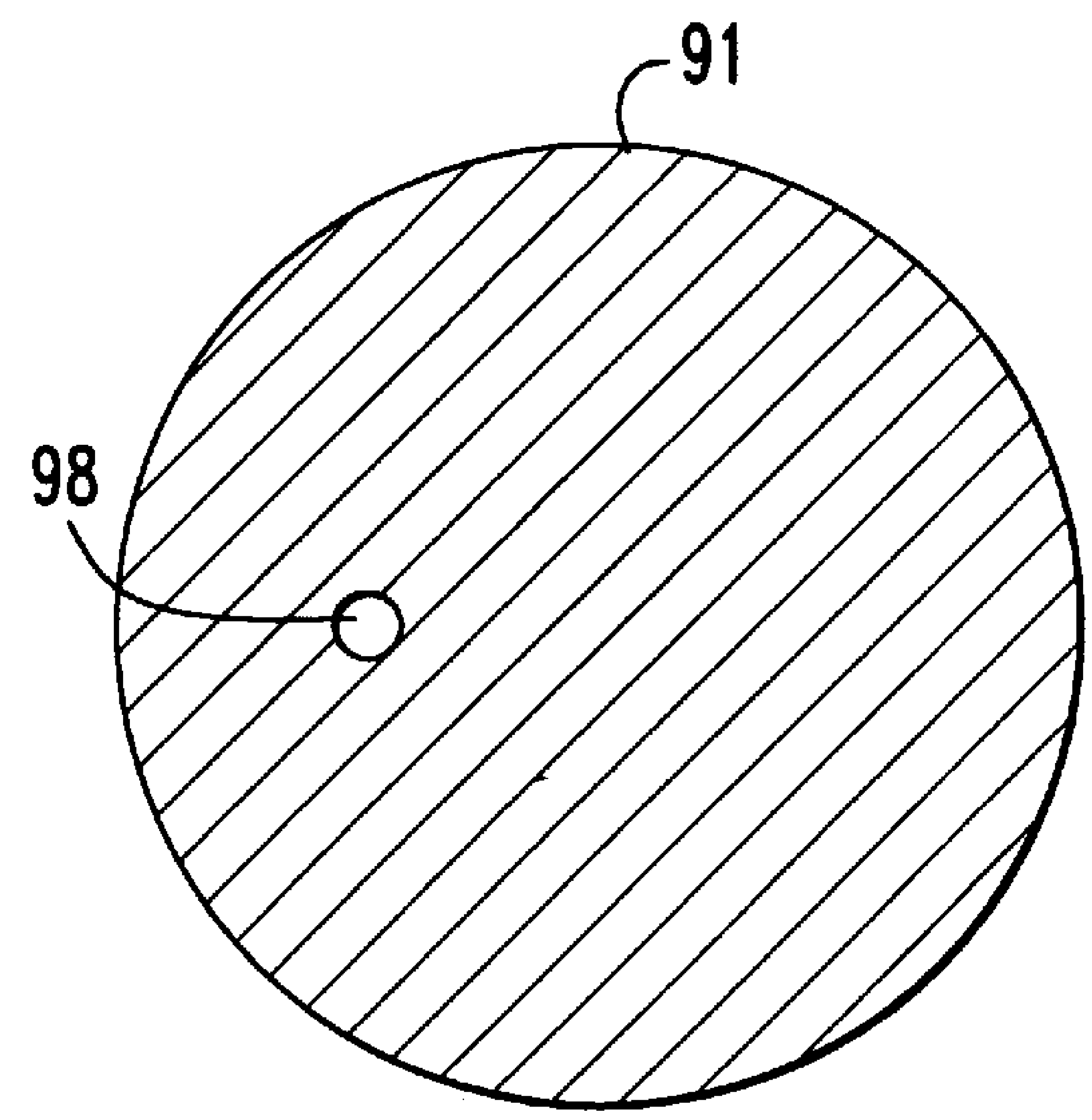


FIG. 4A

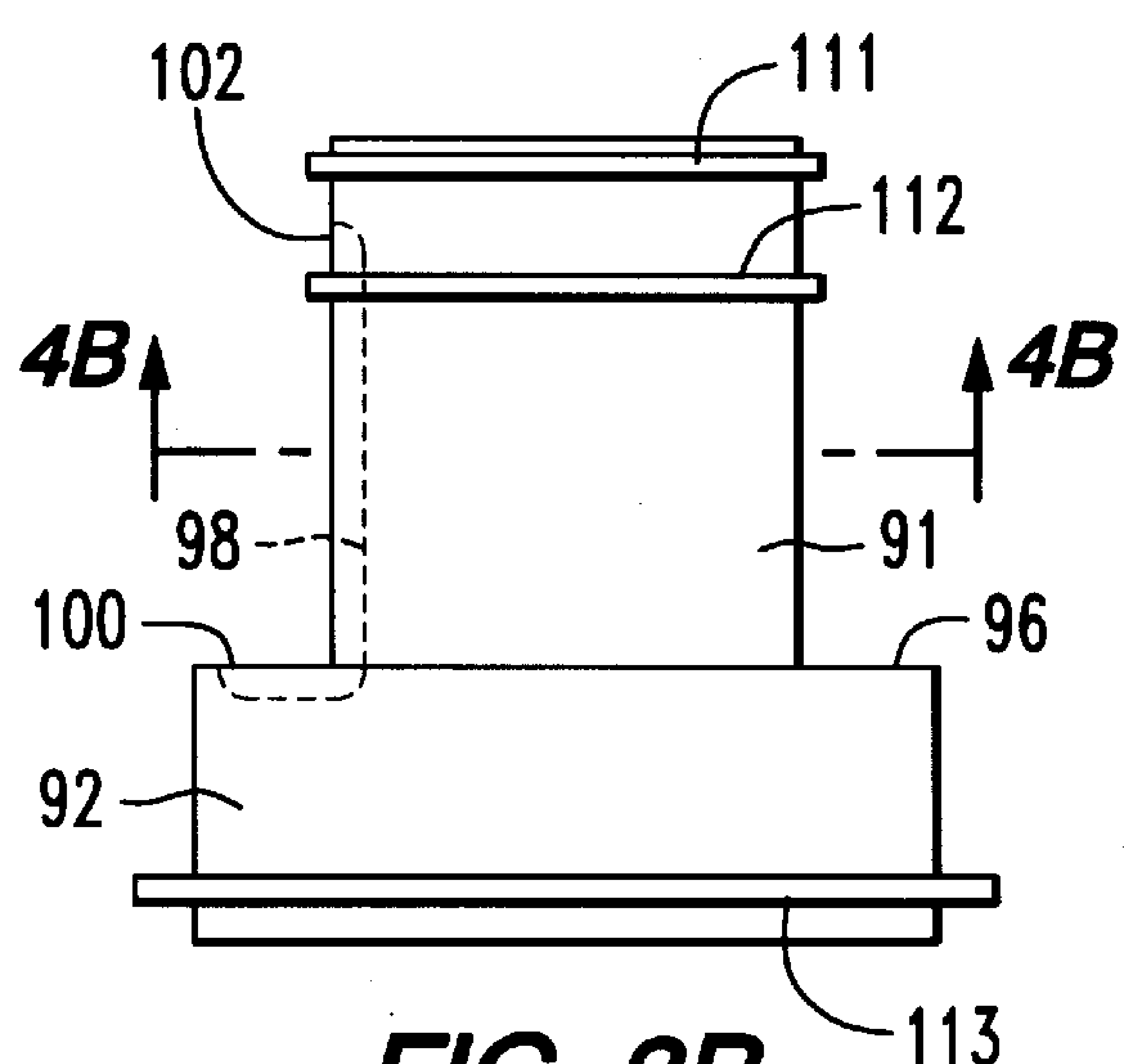


FIG. 3B

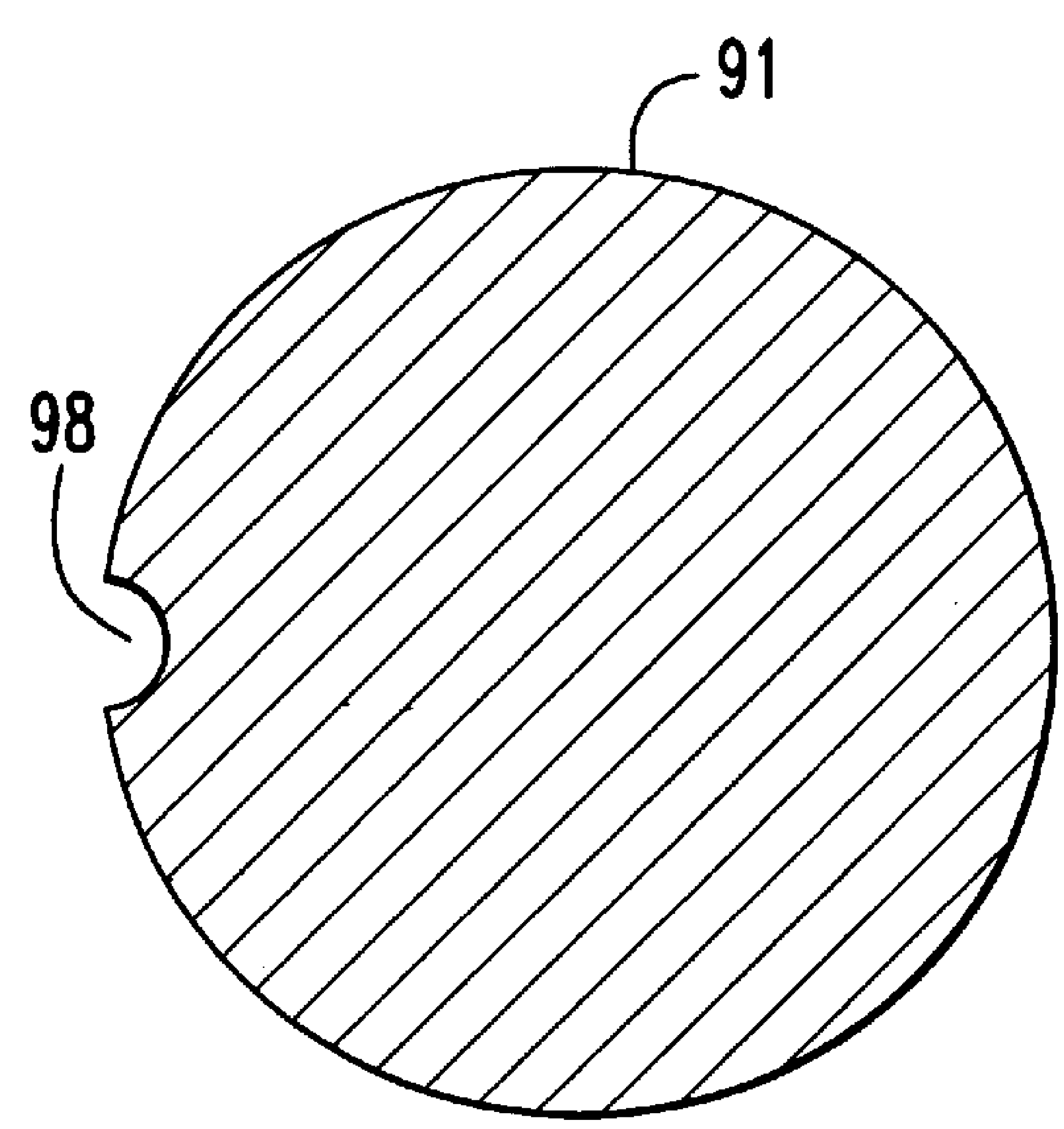


FIG. 4B

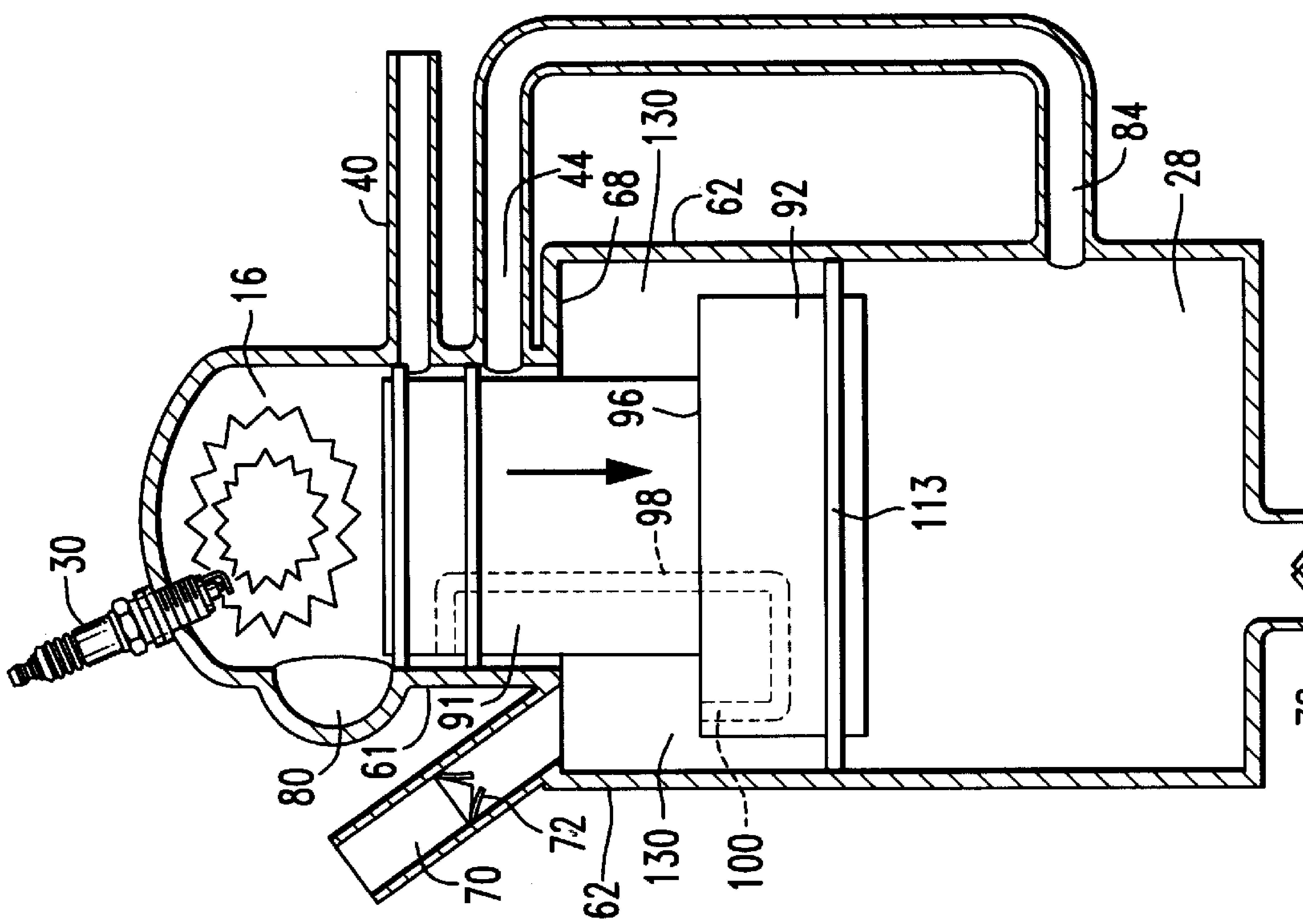

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FIG. 5B

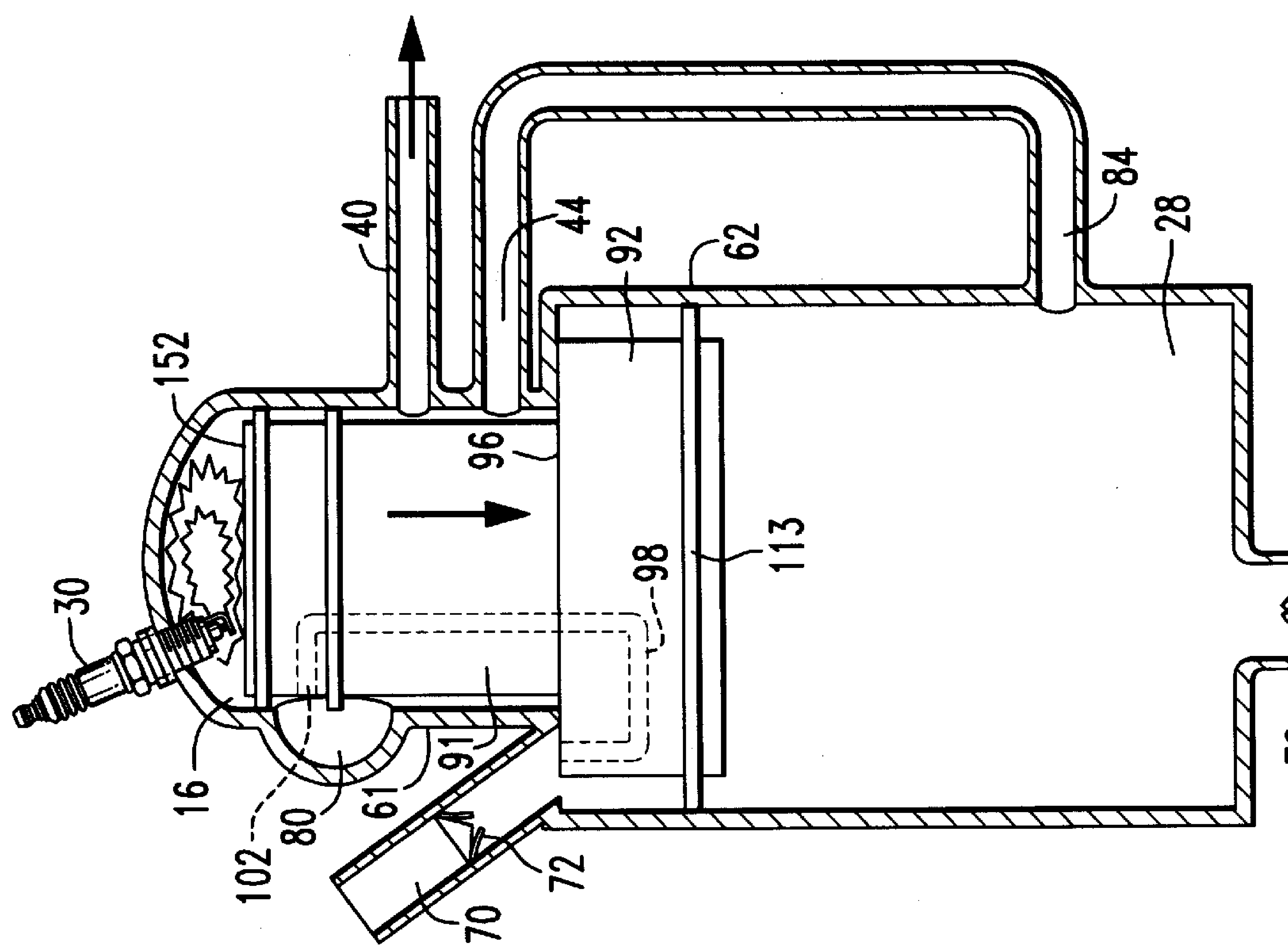
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FIG. 5A

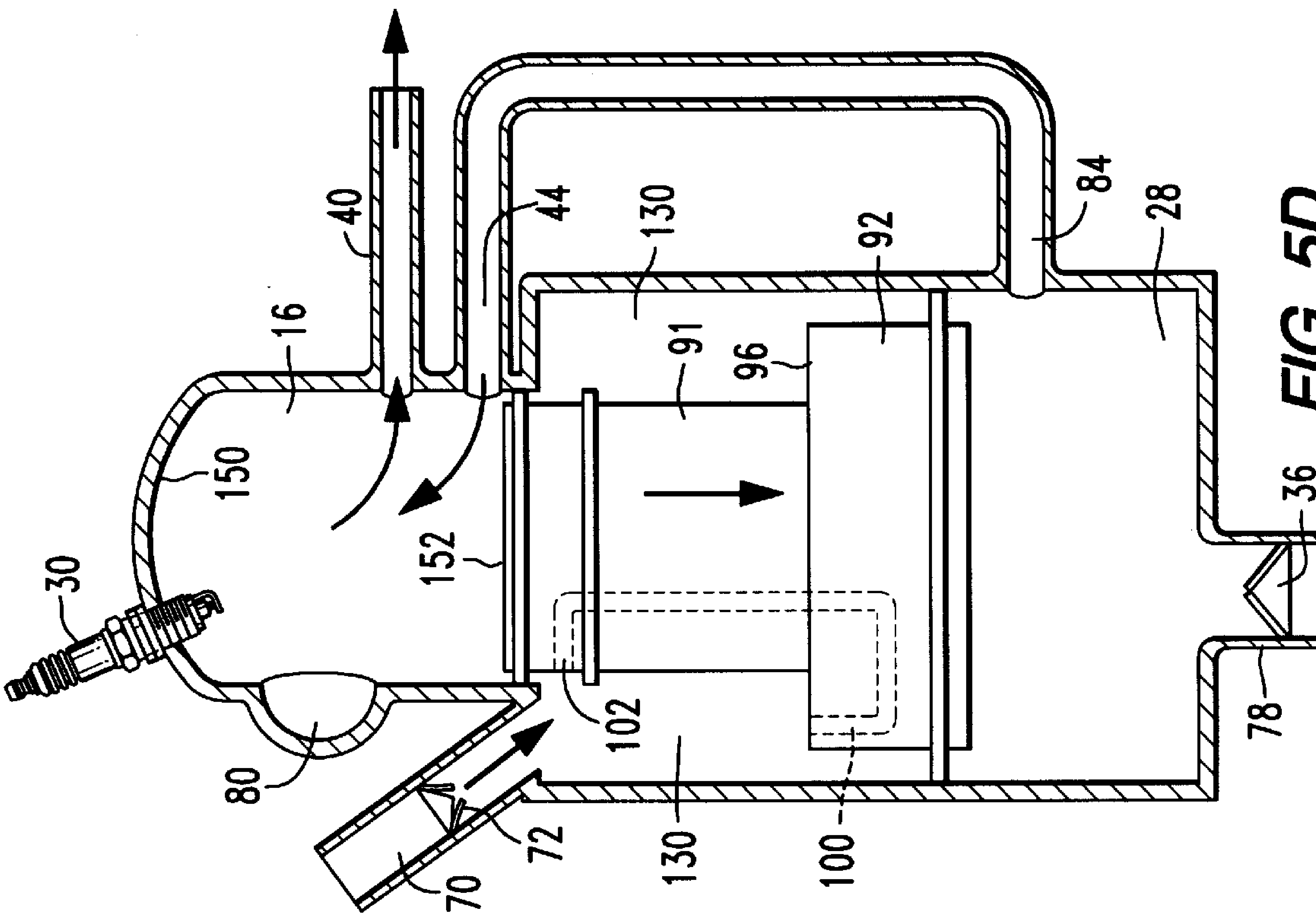
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FIG. 5D

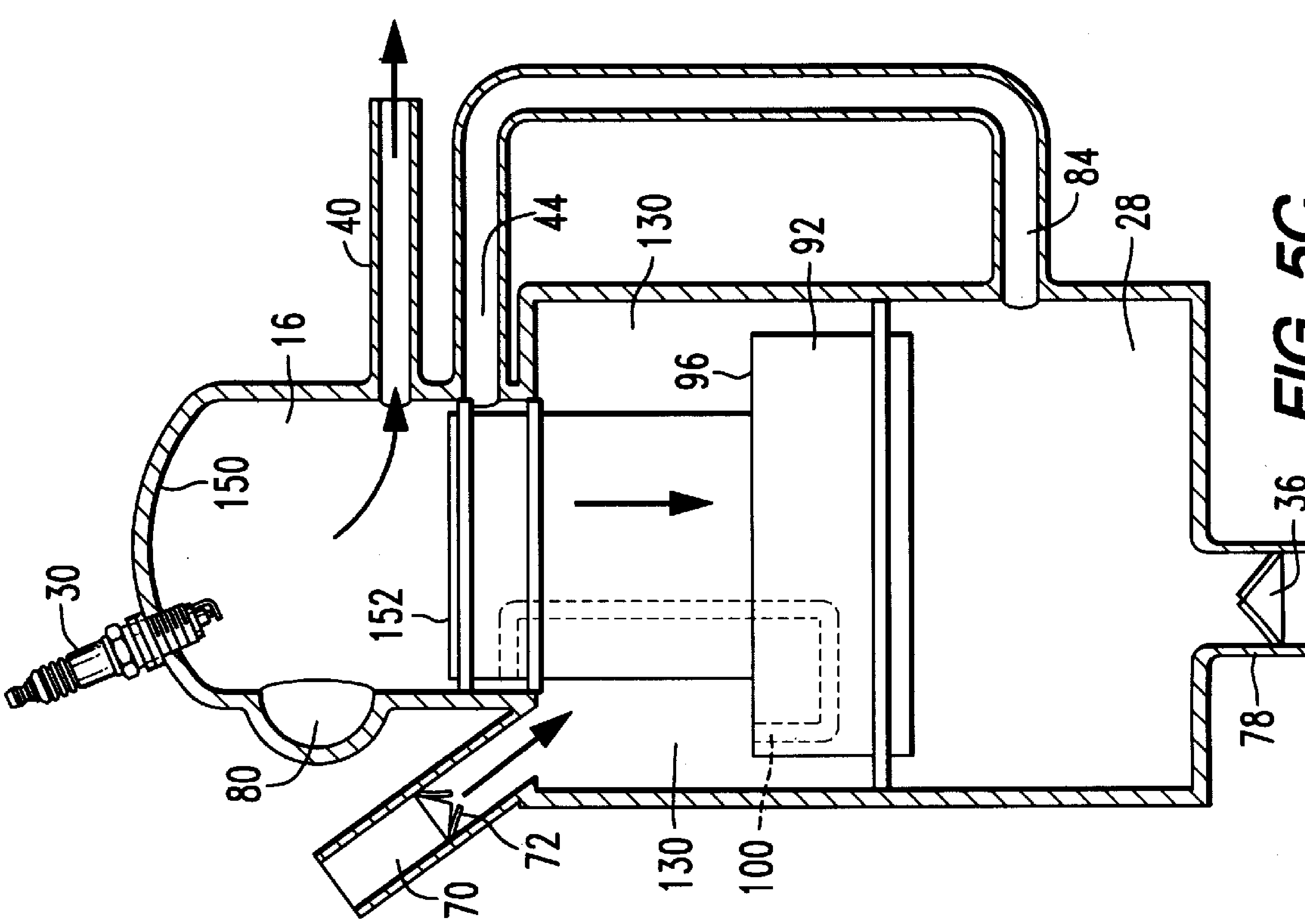
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FIG. 5C

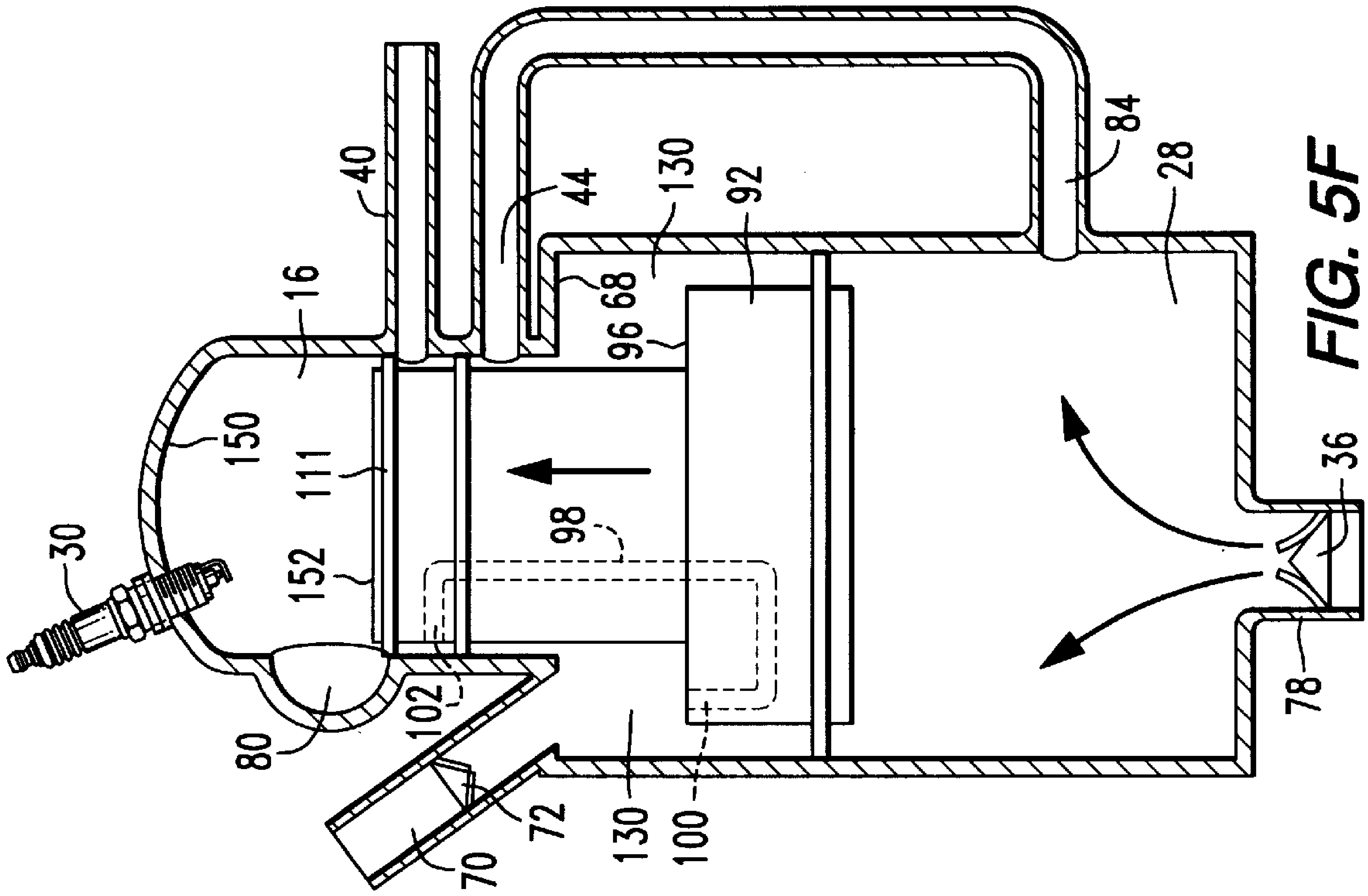
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FIG. 5F

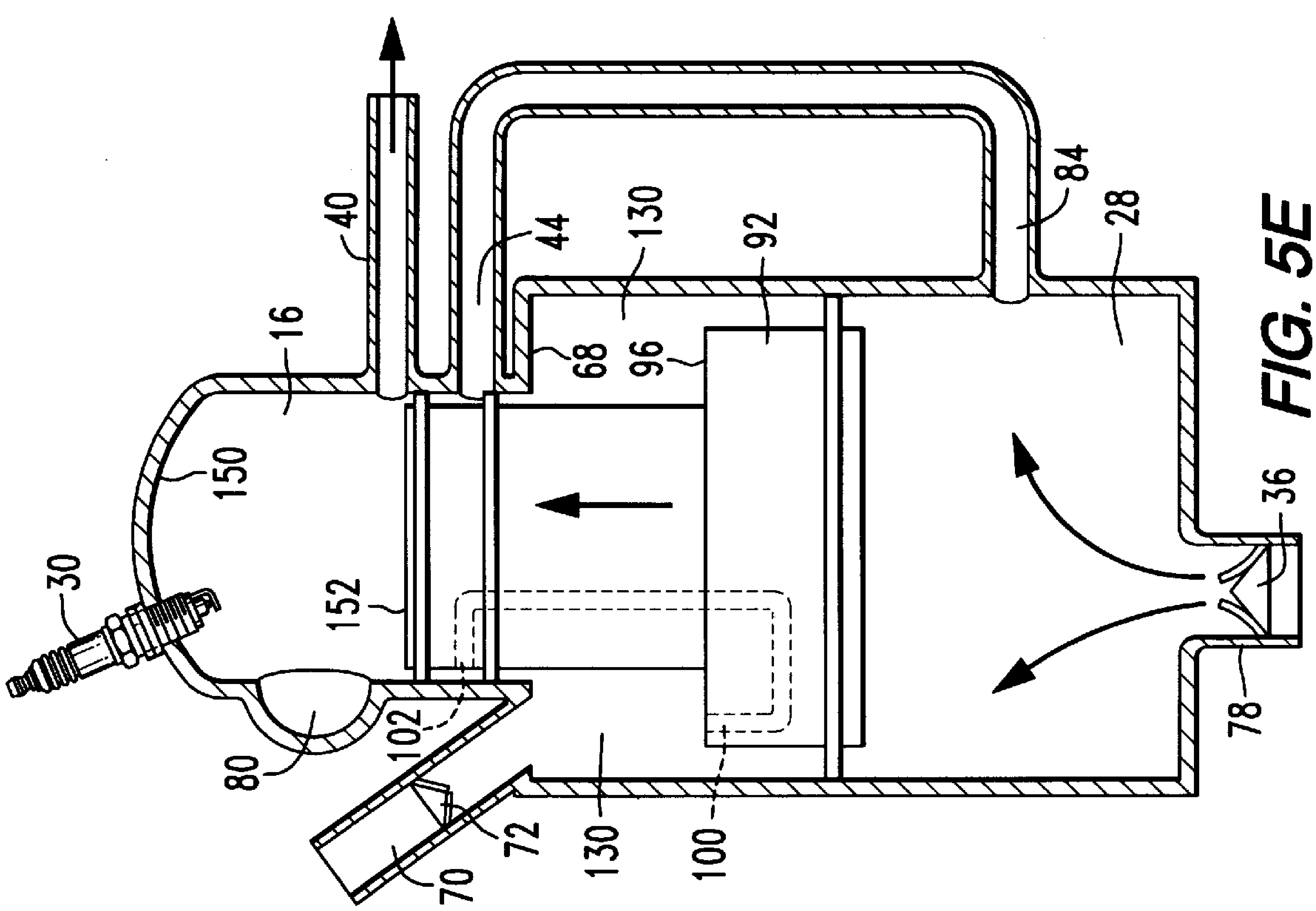
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FIG. 5E

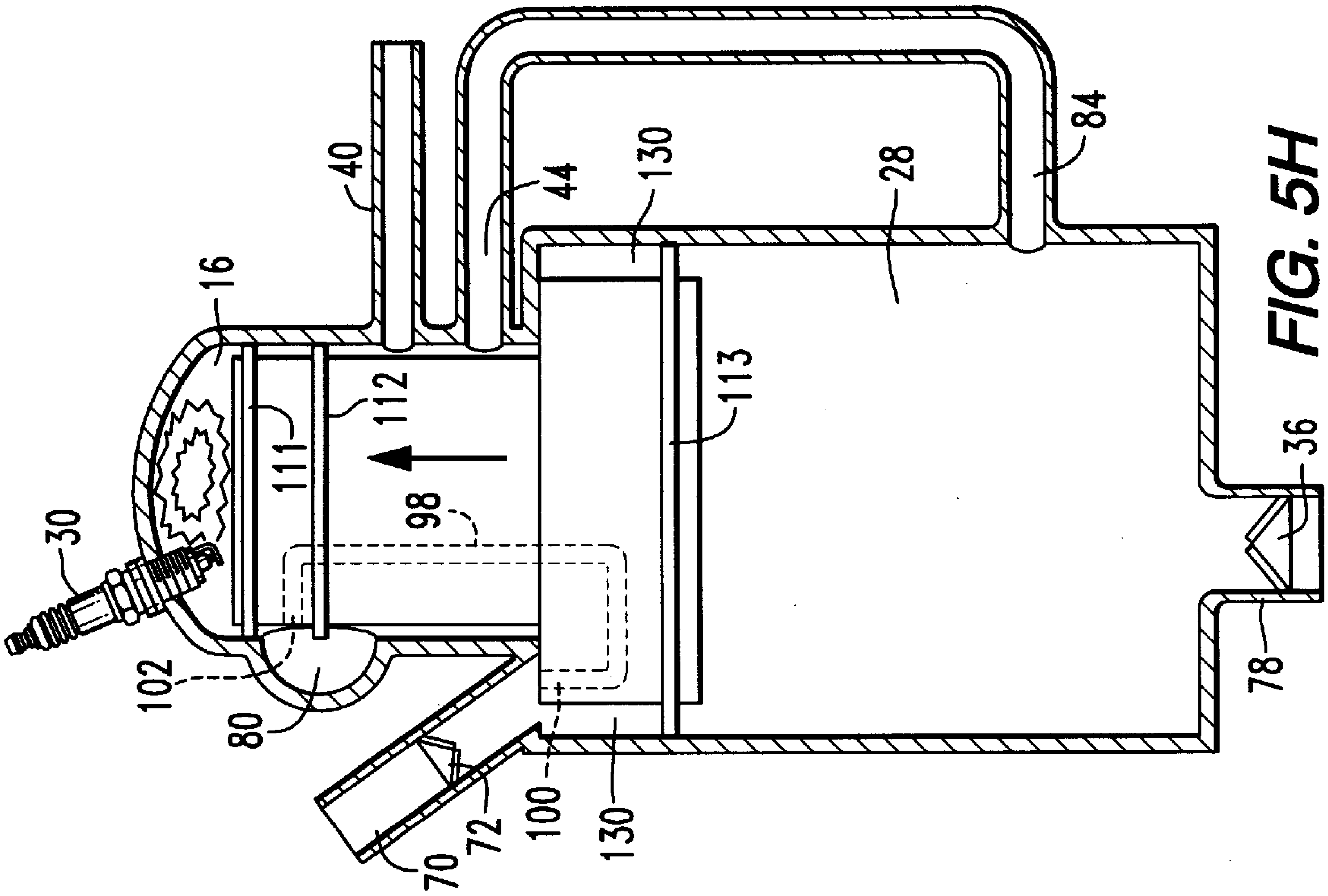

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FIG. 5H

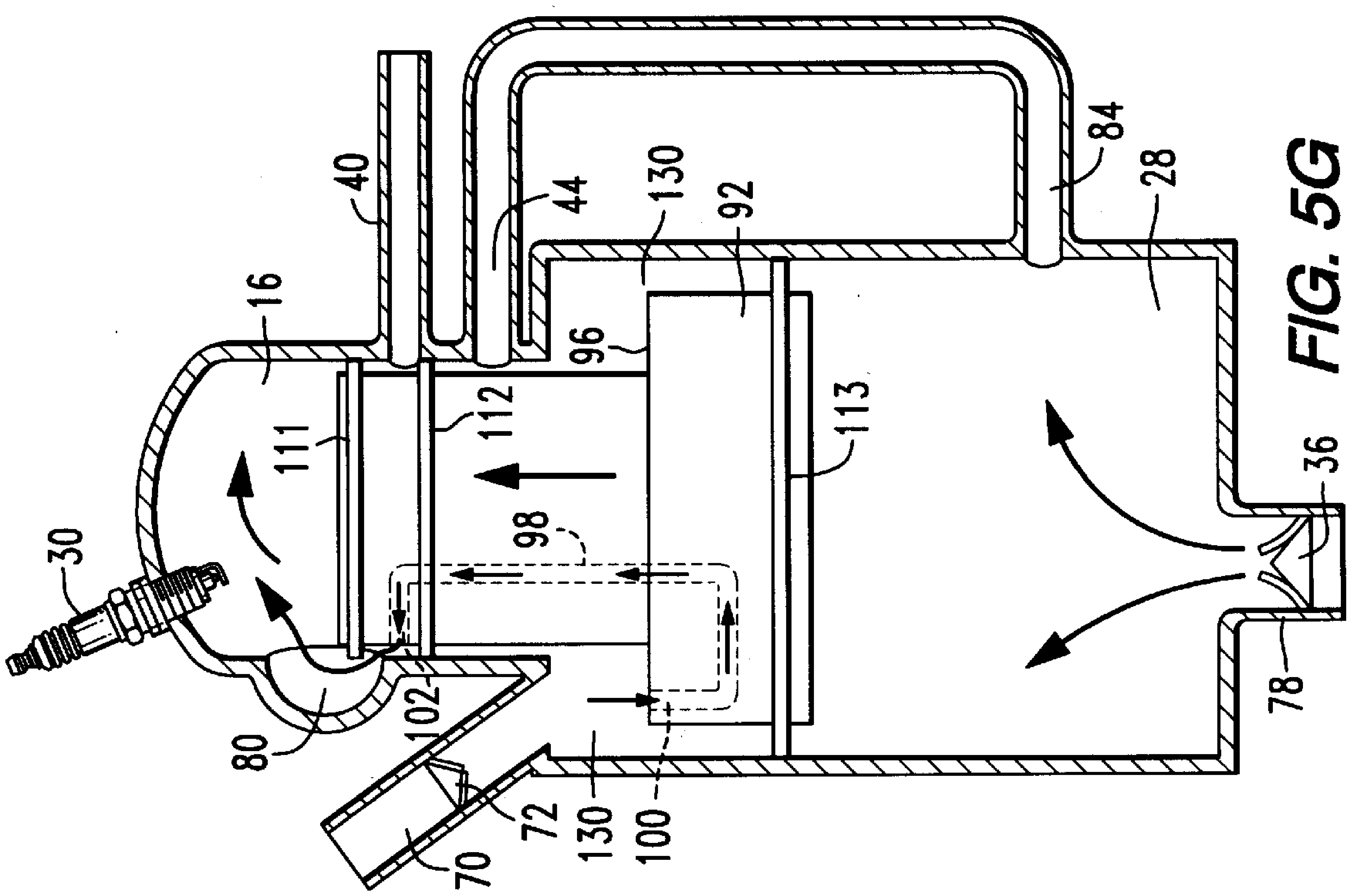

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FIG. 5G

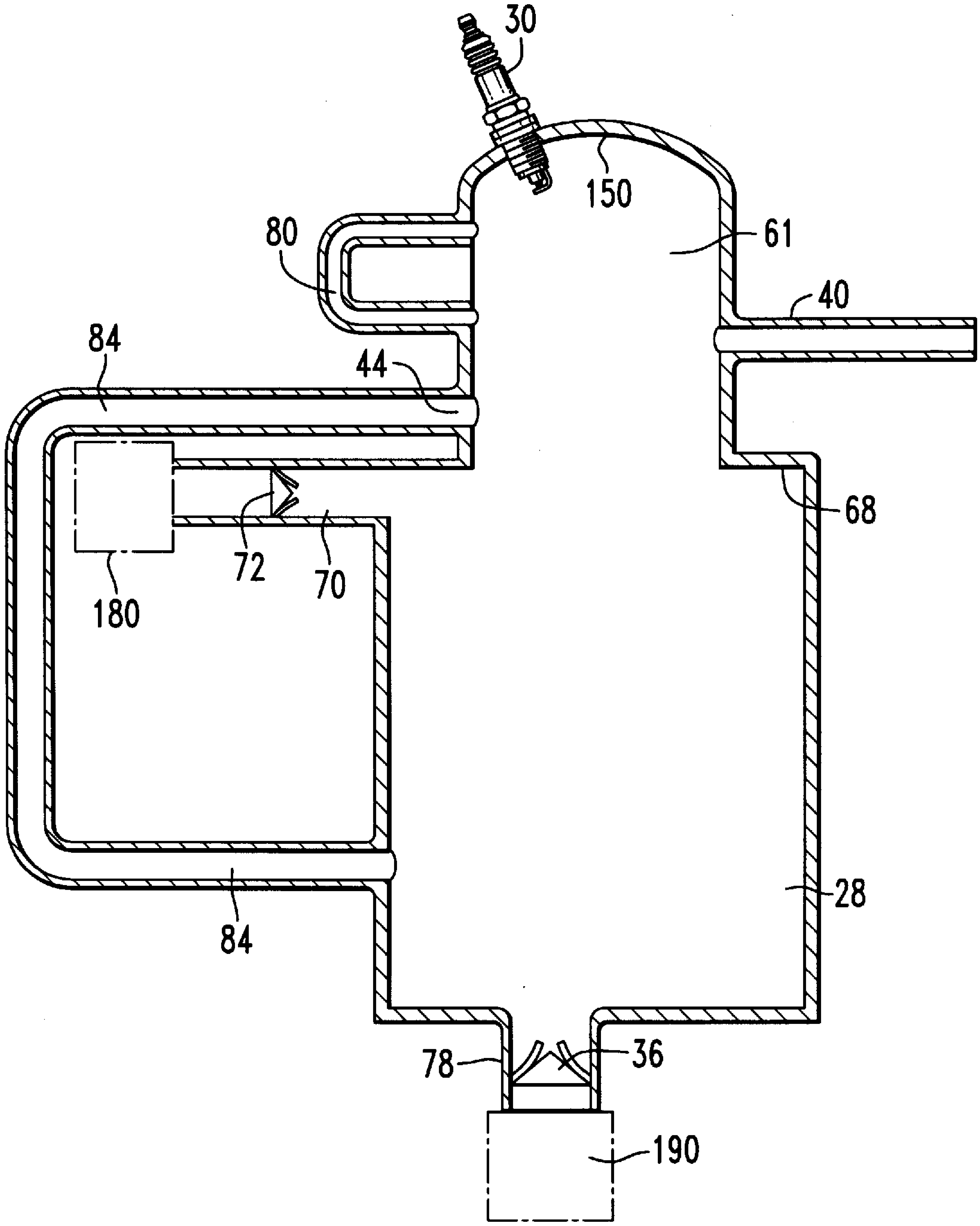
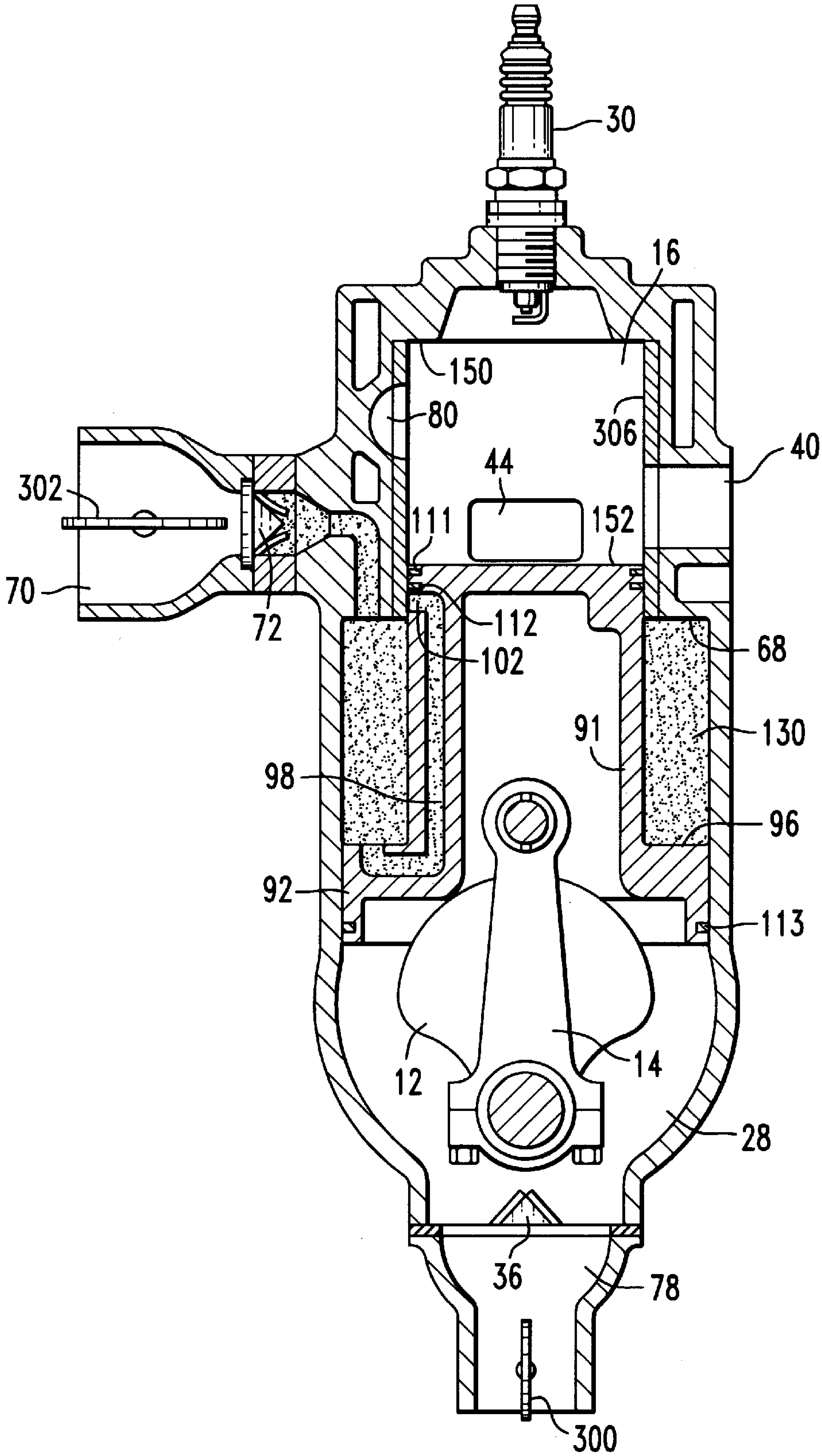


FIG. 6



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302
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112
102
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96
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12
14
28
36
78
300

FIG. 7

LOW EMISSION TWO CYCLE ENGINE USING TWO SEGMENT PISTON

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates generally to internal combustion engines and, more particularly, to an engine which utilizes a piston having two diameters that define a step therebetween which is disposed in a cylinder with two diameters.

2. DESCRIPTION OF THE PRIOR ART

Many different types of internal combustion engines are well known to those skilled in the art. One particular type of engine is a two cycle engine. A common problem that occurs with two cycle engines is that, at low speeds, unburned fuel can be emitted in the exhaust stream. Naturally it is not desirable to exhaust hydrocarbons, in the form of unburned fuel, into the atmosphere for ecological reasons.

The emission of fuel in the exhaust stream can be caused at low speeds by the fact that a fuel/air mixture enters the combustion chamber prior to the exhaust port being closed. Under certain circumstances, the fuel/air mixture can propagate through the combustion chamber and pass out the exhaust port prior to the ignition of the fuel within the combustion chamber.

In certain applications of two cycle engines, fuel injection is used to alleviate this problem. Fuel injectors can be disposed in fluid communication with the combustion chamber, either through a cylinder wall or through the end of the cylinder. One of the goals of these types of solutions is to provide a stratified charge of fuel at one portion of the combustion chamber a distance away from the exhaust port.

U.S. Pat. No. 4,068,629, which issued to Hooper on Jan. 17, 1978, discloses a stepped piston two stroke engine which includes at least two cylinders. Each cylinder has a working part of smaller diameter and a pumping part of larger diameter. The main inlet ports are arranged symmetrically about and spaced from a plane which contains a longitudinal access of the cylinder and which passes through the center of the exhaust port. The auxiliary inlet port is provided in the cylinder wall opposite the exhaust port. Main and auxiliary transfer passages are provided for the main and auxiliary inlet ports. The auxiliary inlet ports and auxiliary transfer passages lie wholly on one side of an axial plane which contains the axes of the two cylinders of the set. The exhaust ports of both cylinders on the other side of this plane. Only air may be supplied to the working part of each cylinder through the main inlet ports, while fuel is injected into the air passing through the auxiliary transfer passages so that a mixture of fuel and air enters the working parts of the cylinders through the auxiliary inlet ports. By this means charge stratification in the working parts of the cylinders can be achieved.

U.S. Pat. No. 4,138,971, which issued to Fujikawa et al on Feb. 13, 1939, describes a crank chamber precompression type two-cycle internal combustion engine which includes a pair of stepped cylinders and a pair of stepped pistons slidably disposed in the cylinders. These define annular spaces of variable volume in the cylinders. The pistons are interconnected to each other with 180 degrees phase difference. An air-fuel mixture is introduced into the annular space in one cylinder and forced into the crank chamber of the other cylinder during the upward stroke of the associated piston, so that an additional charge is provided.

U.S. Pat. No. 4,169,434, which issued to Guenther on Oct. 2, 1979, describes an internal combustion engine with a stepped piston supercharger. A reciprocating piston four cycle internal combustion engine utilizes a stepped piston. The stepped portion of the piston works in an enlarged bore in the block of the engine, and serves as a compressor to provide a supercharged fuel-air mixture into the combustion chamber. The compressor delivers two compression strokes per engine cycle. The compressed fuel-air mixture travels from the compressor via a bypass manifold which also serves as an accumulator. It then passes to the main cylinder via an intake valve. The fuel-air mixture is admitted to the compressor cylinder through the crankcase and valved passages through the stepped portion of the piston.

U.S. Pat. No. 4,210,108, which issued to Hooper on Jul. 1, 1980, discloses a stepped piston two stroke engine which has a stepped piston in which the cylinder casting has a bore of greater diameter to form a pumping part, a bore of lesser diameter to form a working part, exhaust port means in the working part and opposed transfer part means on opposite sides of the working part disposed symmetrically about a plane passing through the longitudinal axis of the cylinder. The plane also passes through the center of the exhaust port means. The transfer port means is of a form to be produced in the casting process by non-separate cores introduced lineally towards the plane.

U.S. Pat. No. 4,522,163, which issued to Hooper on Jun. 11, 1985, describes a stepped piston and a stepped piston engine. The engine has one or more cylinders and each cylinder contains a stepped piston having a pumping part of larger diameter and a working part of smaller diameter. The working part of the piston is slidably in and associated with a working part of the cylinder in which a combustion of a fuel-air mixture takes place. The pumping part of the piston is slidably in and associated with a pumping part of the cylinder. The piston has a body with an interial hollow opening to the outside toward the lower end of the piston. The body comprises a smaller diameter working part which extends from the top of the piston to a step and a larger diameter pumping part extending from the step to a lower end of the piston. At least one piston ring groove is formed in an outer surface of the smaller diameter part and at least one piston ring groove is formed in the outer surface of the large diameter part.

U.S. Pat. No. 5,189,995, which issued to Hooper on Mar. 2, 1983, describes a stepped piston engine that comprises first, second and third step cylinders with each cylinder having a large diameter pumping part and a small diameter working part. A piston is slidable in the cylinder and each piston is coupled to an output shaft of the engine. A first transfer passage transfers the precompressed charge from the large diameter pumping part of the first cylinder to the smaller diameter pumping part of the second cylinder. A second transfer passage transfers precompressed charge from the large pumping part of the second cylinder to the smaller diameter working part of the third cylinder. A third transfer passage transfers precompressed charge from the large diameter pumping part of the third cylinder to the smaller diameter working part of the first cylinder.

One of the many designs for pistons for internal combustion engines is described in an article titled "Hooper's Hope" which was written by Dave Searle and Doug Jackson in the Oct., 1996 issue of Motorcycle Consumer News. This article describes a piston which comprises two portions, one with a diameter that is less than the other. The configuration, because of its physical appearance, is sometimes referred to as "Top Hat" piston. The configuration described in this article utilizes two cylinders, as a cooperative pair, with one cylinder providing an air flow into the combustion chamber of the other cylinder. The design described in this reference requires cylinders to be arranged in such a way that they are able to cooperate with each other in an associated pair.

It would therefore be significantly beneficial if a two cycle engine could be developed which is able to provide a stratified charge into the combustion chamber of the cylinder without the need for complex fuel injection systems.

SUMMARY OF THE INVENTION

In a preferred embodiment of the present invention, an internal combustion engine is provided with an engine block having a cylinder formed therein. The cylinder has a first portion and a second portion. The first portion has a first diameter which is smaller than a second diameter of the second portion. The first and second diameters of the first and second portions of the cylinder define a cylinder step in a wall of the cylinder.

The preferred embodiment of the present invention also comprises a piston having a first portion and a second portion. The first portion has a first diameter which is smaller than a second diameter of the second portion of the piston. The first and second diameters of the first and second portions of the piston define a piston step in an outer surface of the piston. The piston is disposed within the cylinder.

A compression chamber space is defined by the cylinder and piston steps and, in addition, by an outer surface of the first portion of the piston and an inner surface of the second portion of the cylinder. A combustion chamber is defined by an end of the first portion of the cylinder, an end of the first portion of the piston and a wall of the first portion of the cylinder.

A first conduit is connected in fluid communication with the compression chamber to provide a flow of fuel and air into the compression chamber. A transfer passage is formed in the piston. The transfer passage has a first end and a second end. The first end of the transfer passage is disposed in fluid communication with the compression chamber. The second end of the transfer passage is disposed in fluid communication with an opening in an outer cylindrical surface of the first portion of the piston. A transfer port is formed in a wall of the first portion of the cylinder. The transfer port provides fluid communication between the transfer passage and the combustion chamber when the opening of the second end of the transfer passage is aligned with the transfer port.

The first and second portions of the cylinder and the first and second portions of the piston can be disposed in coaxial relation with each other along a common central axis. A first fuel supply device is connected in fluid communication with the first conduit for providing a primary flow of fuel and air into the combustion chamber between the cylinder and piston steps. The first fuel supply device can be a carburetor or a fuel injector.

A particularly preferred embodiment of the present invention further comprises a crankcase in which a crankshaft is disposed. As known to those skill in the art, connecting rods are connected between the crankshaft and the piston in an internal combustion engine. Rotation of the crankshaft is caused by the reciprocating motion of the piston. In one preferred embodiment of the present invention, a second conduit is connected in fluid communication between the crankcase and the first portion of the cylinder. This second conduit typically carries a flow of air from the crankcase into the combustion chamber. In certain particularly preferred embodiments of the present invention, a second fuel supply device is disposed in fluid communication with the crankcase for providing a secondary flow of fuel into the crankcase and into the compression chamber through the second conduit. The second fuel supply device can be a carburetor or a fuel injector.

An exhaust conduit is connected in fluid communication with the first portion of the cylinder. In a typical application of the present invention, the exhaust conduit is connected in fluid communication with the first portion of the cylinder at a location between the end of the first portion of the cylinder and a location where the second conduit is connected in fluid communication with the first portion of a cylinder to provide a flow of air or a fuel/air mixture from the crankcase.

In certain embodiments of the present invention, an igniter is disposed at least partially within the combustion chamber. This igniter can be a sparkplug which is provided with power at a preselected time during the movement of the piston when it is at top dead center or just prior to reaching the top dead center position.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully and completely understood from the reading of the description of the preferred embodiment in conjunction with the drawings, in which:

FIGS. **1A–1D** show various portions of the two cycle process;

FIG. **2** is a highly simplified schematic illustration of a cylinder arrangement in accordance with the present invention;

FIGS. **3A** and **3B** show two alternative embodiments of a piston made in accordance with the present invention;

FIGS. **4A** and **4B** are section views of FIGS. **3A** and **3B**, respectively;

FIGS. **5A–5H** show various stages during the two cycle process for an engine made in accordance with the present invention;

FIG. **6** shows an alternative configuration of a cylinder structure made in accordance with the present invention; and

FIG. **7** shows a more detailed illustration of a cylinder and piston made in accord with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Throughout the description of the preferred embodiment, like components will be identified by like reference numerals.

FIGS. **1A–1D** show the four basic stages of a two cycle engine. In FIG. **1A**, the piston **10** is moving upward as the crankshaft **12** causes the connecting rod **14** to push it in that direction. Although not shown in FIG. **1A**, it should be understood that typical internal combustion engines utilize a plurality of pistons and the pistons are sequenced so that some are rising, as shown in FIG. **1A**, as others are moving downward and providing rotational movement to the crankshaft **12**. In FIG. **1A**, a fuel/air mixture in the combustion chamber **16** is being compressed by the upward movement of the piston **10**. The fuel/air mixture results from the flow of air into an intake **78** and a supply of fuel through a nozzle **22**, past a throttle valve **24** and into the crankcase **28**. As will be described below, the fuel/air mixture within the crankcase **28** is ported into the combustion chamber during another portion of the process.

In FIG. **1B**, a spark from the sparkplug **30** ignites the fuel/air mixture within the combustion chamber **16** and causes it to begin expanding. In FIGS. **1**A and **1**B, the reed valve **36** remains open to allow a flow of air and fuel into the crankcase **28**.

In FIG. **1**C, the rapidly expanding fuel/air mixture that has been ignited by the sparkplug **30** within the combustion chamber **16** forces the piston **10** downward. This downward movement of the piston causes it to move past an exhaust port **40** and open the combustion chamber **16** to the atmosphere. The expanding gases within the combustion chamber **16** pass through the exhaust port **40**. The downward force provided by the rapid expansion of the fuel/air mixture after being ignited by the sparkplug **30** causes the piston **10** to move downward and rotate the crankshaft **12**.

It should be understood that the downward movement of the piston **10** within the cylinder reduces the volume of the crankcase **28**. This reduction in volume increases the pressure. It should also be noted that when the piston **10** is moving downward, this increased pressure causes the reed valve **36** to close.

After passing the exhaust port **40**, the upper edge of the piston **10** passes an inlet port **44**. When this occurs, the higher pressure fuel/air mixture within the crankcase **28** flows from the crankcase through the cylinder inlet port **44** and into the combustion chamber **16**. The flow of the fuel/air mixture into the combustion chamber **16** also assists in forcing the exhaust gases out of the exhaust port **40**.

As can be seen in FIG. **1**D, the flow of fuel through the inlet port **44** occurs while the exhaust port **40** is opened. This permits the possibility of unburned fuel passing directly from the cylinder inlet port **44** to the exhaust port **40** prior to the ignition of the mixture in the combustion chamber **16**. This passage of unburned fuel through the exhaust port **40** emits hydrocarbons into the air and is highly undesirable. The emission of fuel in the exhaust stream is most likely to occur during times when the internal combustion engine is running at idle speed.

FIG. **2** illustrates, in a highly simplified schematic figure, the components of an internal combustion engine made in accordance with the concept of the present invention. The cylinder, which is typically formed in an engine block, comprises a first portion **61** and a second portion **62**. The first and second portions of the cylinder are generally cylindrical in shape and are coaxial with each other along axis **64**. The difference in the diameters between the first and second portions of the cylinder defines a cylinder step **68**. At the top of the first portion **61**, a sparkplug **30** is disposed for igniting a fuel/air mixture within the combustion chamber **16**. The exhaust port **40** is shown being connected in fluid communication with the combustion chamber **16**. In addition, the inlet port **44** is shown connected in fluid communication with the crankcase **28**. A first conduit **70** is provided to allow a fuel/air mixture to be transmitted into an area of the cylinder near the cylinder step **68**. More specifically, as will be described in greater detail below, the fuel/air mixture is provided through the first conduit **70** into a compression chamber that is defined by the cylinder step **68** and a piston step that will be described below. A reed valve **72** provides a unidirectional flow of the fuel/air mixture through the first conduit **70** and into this compression chamber. Near the bottom of the second portion **62** of the cylinder, an intake conduit **78** allows air to pass into the crankcase **28**. The reed valve **36** is generally similar to the reed valve described above in conjunction with FIGS. **1**A–**1**D and serves a similar purpose. However, unlike the reed valve **36** described in conjunction with FIGS. **1**A–**1**D, the reed valve **36** and the intake conduit **78** are not always

used to pass a fuel/air mixture into the crankcase **28**. In the present invention, certain embodiments do not cause fuel to be entrained within the air stream. Instead, only air flows through the intake conduit **78** in certain embodiments of the present invention.

With continued reference to FIG. **2**, a transfer port **80** is also shown. The transfer port **80** is formed in the wall of the first portion **61** of the cylinder. Its function will be described in greater detail below. Also in FIG. **2**, a second conduit **84** is provided to connect the crankcase **28** in fluid communication with the cylinder inlet port **44**.

FIG. **3**A shows a piston made in accordance with one embodiment of the present invention. The piston has a first portion **91** and a second portion **92**. The first and second portions of the piston have different diameters and these different diameters define a piston step **96** therebetween. A transfer passage **98** is a conduit that is formed within the body of the piston and has a first end **100** and a second end **102**. The first end **100** is connected in fluid communication with a region proximate the piston step **96**. As will be discussed in greater detail below, this places the transfer passage **98** in fluid communication with a compression chamber that is formed between the piston step **96** and a cylinder step **98**.

With continued reference to FIG. **3**A, three piston rings are illustrated. These piston rings, **111**, **112** and **113**, assist in providing a seal between the piston and the inner cylindrical walls of the cylinder. Although used in most internal combustion engines, these piston rings are not required in all embodiments of the present invention. However, in a preferred embodiment of the present invention, piston rings are used for these known purposes and the second end **102** and the transfer passage **98** is disposed between the two upper piston rings, **111** and **112**.

FIG. **3**B shows an alternative embodiment of the piston. In FIG. **3**B, the transfer passage **98** is not formed as a hole that is completely surrounded by the body of the piston. Instead, it is a groove formed in the piston step **96** and the outer surface of the first portion **91** of the piston. The transfer passage **98** is surrounded by the piston in which it is formed and the cylindrical wall of the first portion **61** of the cylinder. In the manner described above, its first end **100** and second end **102** operate to connect the compression chamber above the piston step **96** with the second end **102**.

FIGS. **4**A and **4**B are section views of FIGS. **3**A and **3**B, respectively. In FIG. **4**A, the first portion **91** of the piston is shown with the transfer passage **98** formed, as a generally circular hole, along a portion of the piston body. This provides the required conduit to transmit a fuel/air mixture from the first end **100** of the transfer passage **98** to its second end **102** as described above.

FIG. **4**B shows a section view of the alternative embodiment illustrated in FIG. **3**B. The first portion **91** of the piston has a groove formed in its outer surface to serve as the transfer passage. When the piston is disposed within the cylinder, the cylindrical wall of the cylinder cooperates with the groove in the outer surface of the piston to define a fluid passage through which the fuel and air mixture can move from the first end **100** to the second end **102** of the transfer passage **98**.

FIG. **5**A shows the piston of FIG. **3**A assembled in association with the cylinder of FIG. **2**. As can be seen, the first portion **91** of the piston is disposed in the first portion **61** of the cylinder and the second portion **92** of the piston is disposed in the second portion **62** of the cylinder. In the particularly preferred embodiment illustrated in FIG. **5**A, the first and second portions of the pistons and the first and second portions of the cylinder are arranged in coaxial association with each other about a common axis, such as axis **64** shown in FIG. **2**. The sequence of operations performed by the piston and cylinder will be described below in conjunction with FIGS. **5A–5H**.

In FIG. **5A**, the sparkplug **30** has caused the fuel/air mixture in the combustion chamber **60** to ignite. The rapidly expanding gas within the combustion chamber **16** begins to cause the piston to move downward as represented by the arrow. The downward movement of the piston increases the pressure within the crankcase **28** because of the reducing volume within the crankcase. Reed valve **36** is closed, thereby preventing flow of air out of the crankcase **28** through the intake passage **78**. Reed valve **72** begins to open in response to the downward movement of the piston and a fuel/air mixture is allowed to pass through the first conduit **70** into the region above the piston step **96**.

FIG. **5B** shows the piston at a time subsequent to that shown in FIG. **5A**. The expanding gas within the combustion chamber **16** continues to force the piston downward. A compression chamber **130** is more clearly shown in FIG. **5B**. This compression chamber **130** is defined by the cylinder step **68**, the piston step **96** and the cylindrical wall of the second portion **62** of the cylinder. The continued downward movement of the piston maintains the reed valve **36** in a closed position and the reed valve **72** in a opened position. This allows a fuel/air mixture to flow through the first conduit **70** into the compression chamber **130**. It should be noted that the exhaust port **40** and the cylinder inlet port **44** are still closed by the presence of a piston in overlapping association therewith. Therefore, no flow is passing through the exhaust port **44** from the combustion chamber **16** and no flow is passing from the crankcase **28** through the second conduit **84** toward the cylinder inlet port **44**. However, the compression chamber **130** is expanding and filling with a fuel/air mixture provided through the first conduit **70**.

In FIG. **5C**, the piston has moved downward sufficiently to expose the exhaust port **40**. This allows the burned or burning fuel/air mixture to leave the combustion chamber **16** and pass through the exhaust port **40** to the atmosphere. It should be noted that the cylinder inlet port **44** is not yet exposed by the piston. In FIG. **5C**, the end of the cylinder is identified by reference numeral **150** and the top of the piston is identified by reference numeral **152**. The combustion chamber **16** is defined as the space between the end **150** of the cylinder and the top **152** of the piston. The gas is shown, by the arrow, flowing out of the combustion chamber **16** and through the exhaust port **40**. The fuel/air mixture is shown flowing through the reed valve **72** into the compression chamber **130** and reed valve **36** is shown as blocking flow out of the crankcase **28**. The pressure within the crankcase **28** continues to increase because of the continued further movement of the piston downward. This downward movement of the piston decreases the volume of the crankcase **28** and thereby raises its pressure.

In FIG. **5D**, the piston is shown at its downward extreme of travel. At this point of its travel, the top **152** of the piston has exposed the cylinder inlet port **44**. This allows the high pressure gas within the crankcase **28** to pass through the second conduit **84** and the cylinder inlet port **44** into the combustion chamber **16**. It should be noted that the exhaust port **40** remains open and exhaust gases continue to flow from the combustion chamber **16** into the exhaust port **40**. It should be understood that, although the cylinder inlet port **44** and the exhaust port **40** are shown at the same side of the cylinder in FIG. **5D**, a typical application would place the port at opposite sides of the cylinder. For purposes of illustrating the basic concepts of the present invention, which are not limited by the specific locations of the exhaust port and cylinder inlet port, these two devices are shown on a common side of the figure.

With the continued reference to FIG. **5D**, reed valve **72** remains open, but will be closed as soon as the piston begins to move upward from its bottom dead center position. The fuel/air mixture within the compression chamber **130** will then be trapped between the cylinder step and the piston step within the angular shape defined between the outer cylindrical surface of the first portion **91** of the piston and the inner cylindrical surface of the second portion of the cylinder.

In FIG. **5E**, the piston has begun to travel upward within the cylinder. The cylinder inlet port **44** is now closed by the piston, but the exhaust port **40** remains open. The upward movement of the piston causes reed valve **36** to open and permit air to flow through the intake conduit **78** into the crankcase **28**. The crankcase **28** will continue to fill with air passing through the reed valve **36** as long as the cylinder inlet port **44** remains closed by the location of the piston. The fuel/air mixture within the compression chamber **130** is being pressurized by the upward movement by the piston step **96** toward the cylinder step **68**. Reed valve **72** is closed to prevent passage of the fuel/air mixture away from the compression chamber **130** through the first conduit **70**.

FIG. **5F** shows the position of the piston as it moves past the exhaust port **40** to close it. Reed valve **36** remains open and air continues to flow into the crankcase **28** through the intake conduit **78**. The fuel/air mixture within the compression chamber **130** continues to be compressed and its pressure continues to rise as the volume defined between the cylinder step **68** and the piston step **96** continues to decrease. It should be noted that in FIG. **5F**, the exhaust port **40** is closed, but the upper piston ring **111** has not yet exposed the second end **102** of the transfer passage **98** to the transfer port **80**. Therefore, the pressure within the compression chamber **130** continues to rise in response to the upper movement of the piston.

FIG. **5G** shows the present invention as the upper piston ring **111** allows fluid communication between the second end **102** of the transfer passage **98** and the transfer port **80**. When the piston is in the position shown in FIG. **5G**, air continues to flow through reed valve **36** to fill the crankcase **28**, but the air is not permitted to flow through the second conduit **84** because the cylinder inlet port **44** is blocked by the piston. In FIG. **5G**, it can be seen that the fuel/air mixture trapped in the compression chamber **130** can now flow from the compression chamber into the first end of the transfer passage **98** and toward the second end **102**. From the opening in the piston wall, where the second end **102** is located, the fuel/air mixture can leave the transfer passage **98** and enter the transfer port **80**. The transfer port, in a typical application of the present invention, is a localized depression within the cylinder wall of the first portion of the cylinder. It allows the fuel/air mixture to leave the second end **102** of the transfer passage **98** and flow around the upper piston ring **111** into the combustion chamber **16**. It is important to note that the exhaust port **40** is closed in FIG. **5G** prior to the flow of fuel/air mixture into the combustion chamber **16**. This prevents the chance of hydrocarbons escaping directly out of the exhaust port **40** prior to ignition by the sparkplug **30**. As the piston continues to rise, the fuel/air mixture will flow through the transfer port **80** until it is blocked by the continued upward movement of the upper piston ring **111**.

With continued reference to FIG. **5G**, reed valve **72** is closed and reed valve **36** is opened. The crankcase continues to fill with air and the fuel/air mixture in the compression chamber **130**, which has reached its maximum pressure magnitude because of the significant decrease in the volume of the compression chamber **130**, moves rapidly through the transfer passage **98** and transfer port **80** into the combustion chamber **16**.

In FIG. **5H**, the piston has reached, or is reaching, its top dead center maximum upward position. The upper piston ring **111** has closed the transfer port **80** and has sealed the combustion chamber **16** from all alternative passages. The compression chamber **130**, described above, has been reduced to vitually no volume. The exhaust port **40** and the cylinder inlet port **44** are closed by the location of the piston. The transfer port **80** is closed as is the transfer passage **98**, with respect to the combustion chamber **16**. The sparkplug **30** ignites the fuel/air mixture within the combustion chamber to begin the process of forcing the piston downward as was described above in conjunction with FIG. **5A**.

With reference to FIGS. **5A–5H**, it can be seen that the present invention provides a means by which a fuel/air mixture can be injected into the combustion chamber **16** under high pressure after the exhaust port **40** is closed. This eliminates the potential emission of hydrocarbons that flow directly out of the exhaust port without being burned. In addition, this is accomplished without the need for the need for expensive fuel injection systems.

FIG. **6** shows an alternative configuration of the present invention. The purpose of FIG. **6** is to show that the specific locations of the various ports and conduits with respect to the first and second portions of the cylinder are not limiting to the present invention. In addition, FIG. **6** is intended to show the fact that the fuel supply means used to create the fuel/air mixture can either be a carburetor or a fuel injector. In addition, the intake conduit **78** can be provided with a secondary fuel supply.

In FIG. **6**, the cylinder inlet port **44** is shown disposed on an opposite side of the first portion **61** of the cylinder from the exhaust port **30**. This arrangement is more typical than that shown in FIGS. **5A–5H**. In addition, the transfer port **80** comprises a conduit as shown in FIG. **6** rather than a simple depression formed in the wall of the first portion of the cylinder, as illustrated in FIGS. **5A–5H** and described above. These various embodiments of the port and conduits are within the scope of the present invention.

Dashed box **180** represents a first fuel supply device that provides the fuel which flows into the compression chamber **130** (not shown in FIG. **6**) defined between the cylinder step **68** and the piston step **96** (not shown in FIG. **6**). The first fuel supply device **180** can be a carburetor or a fuel injector. The adaptation of either of these components is within the scope of knowledge of those skilled in the art of internal combustion engines.

In the above description of the intake conduit **78**, it was described as being intended to allow air to flow into the crankcase **28**. In known internal combustion engines, fuel is introduced into the crankcase **28** in the form of a fuel/air mixture which then passes through an air inlet, such as that identified by reference numeral **44**. In a preferred embodiment of the present invention, the primary flow of the fuel/air mixture is not introduced through the intake conduit **78** but, instead, through the first conduit **70** into the compression chamber. However, it should be understood that alternative embodiments of the present invention could incorporate a secondary fuel/air system that provides a second fuel device **190** at the intake conduit **78**. This second fuel supply device **190** can be a carburetor or a fuel injector. If the first and second fuel supply devices, **180** and **190**, are carburetors, a typical embodiment of the device would include a two segment carburetor for these purposes. In operation, a typical application of the present invention would activate the first fuel supply device **180** during normal running, particularly at idle speed. The second fuel supply device **190** would be used at higher speeds and when the internal combustion engine experiences higher loads. When used, the second fuel supply device **190** would be a secondary fuel supply and the fuel/air mixture provided through the crankcase **28** and the cylinder inlet port **44** would be in addition to the primary fuel supply provided by the first fuel supply device **180** into the compression chamber.

FIG. **7** shows an embodiment of the present invention with more detail relating to the structure of the engine block and the various components described above. As shown in FIG. **7**, the piston is at its bottom dead center position. The two upper pistons rings, **111** and **112**, are below the exhaust port **40** and the transfer port **44**. Reed valve **36** is closed and reed valve **72** is open. However, it should be understood that as the piston moves upward from its bottom dead center position, reed valve **72** will close and reed valve **36** will open. The compression chamber **130** is at its maximum volume when the piston is at the bottom dead center position. The reference numerals shown in FIG. **7** are described above in detail with respect to FIGS. **5A–5H**. In addition, two rotatable plates are shown in FIG. **7**. One throttle plate **300** is shown in intake passage **78** and another throttle plate **302** is shown in the first conduit **70**. In addition, a liner **306** is provided in the first portion of the cylinder.

With continued reference to FIG. **7**, it should be noted that in this embodiment the inlet port **44** and the exhaust port **40** are in partial axial overlapping positions. In other words, as the piston moves upward in FIG. **7**, the inlet port **44** is not completely covered prior to the exhaust port **40** being partially covered.

Although described in considerable detail and illustrated with particular specificity, it should be understood that the present invention can also be used in alternative embodiments which are also within its scope.

I claim:

1. An internal combustion engine, comprising:

an engine block having a cylinder formed therein, said cylinder having a first portion and a second portion, said first portion having a first diameter which is smaller than a second diameter of said second portion, said first and second diameters of said first and second portions of said cylinder defining a cylinder step in a wall of said cylinder;

a piston having a first portion and a second portion, said first portion having a first diameter which is smaller than a second diameter of said second portion, said first and second diameters of said first and second portions of said piston defining a piston step in an outer surface of said piston, said piston being disposed within said cylinder;

a compression chamber being bounded by said cylinder and piston steps, an outer surface of said first portion of said piston and an inner surface of said second portion of said cylinder;

a combustion chamber being bounded by an end of said first portion of said cylinder, an end of said first portion of said piston and a wall of said first portion of said cylinder;

a first conduit connected in fluid communication with said compression chamber;

a transfer passage formed in said piston, said transfer passage having a first end and a second end, said first end being disposed in fluid communication with said compression chamber, said second end being disposed in fluid communication with an opening in a surface of said first portion of said piston; and

a transfer port formed in a wall of said first portion of said cylinder, said transfer port providing fluid communication between said transfer passage and said combustion chamber when said opening is aligned with said transfer port.

2. The internal combustion engine of claim **1**, wherein:

said first and second portions of said cylinder are disposed in coaxial relation with each other along a first axis; and

said first and second portions of said piston are disposed in coaxial relation with each other along a second axis, said first and second axes being aligned with each other.

3. The internal combustion engine of claim **1**, further comprising:

a first fuel supply device connected in fluid communication with said first conduit for providing a primary flow of fuel and air into said compression chamber.

4. The internal combustion engine of claim **3**, wherein:

said first fuel supply device is a carburetor.

5. The internal combustion engine of claim **3**, wherein:

said first fuel supply device is a fuel injector.

6. The internal combustion engine of claim **3**, further comprising:

a crankcase;

a second conduit connected in fluid communication between said crankcase and said first portion of said cylinder.

7. The internal combustion engine of claim **6**, further comprising:

a second fuel supply device disposed in fluid communication with said crankcase for providing a secondary flow of fuel into said crankcase and into said compression chamber through said second conduit.

8. The internal combustion engine of claim **7**, wherein:

said second fuel supply device is a carburetor.

9. The internal combustion engine of claim **7**, wherein:

said second fuel supply device is a fuel injector.

10. The internal combustion engine of claim **1**, further comprising:

an exhaust conduit connected in fluid communication with said first portion of said cylinder.

11. The internal combustion engine of claim **6**, wherein:

said exhaust conduit is connected in fluid communication with said first portion of said cylinder at a location between said end of said first portion of said cylinder and a location where said second conduit is connected in fluid communication with said first portion of said cylinder.

12. The internal combustion engine of claim **1**, further comprising:

an igniter disposed at least partially within said combustion chamber.

13. An internal combustion engine, comprising:

an engine block having a cylinder formed therein, said cylinder having a first portion and a second portion, said first portion having a first diameter which is smaller that a second diameter of said second portion, said first and second diameters of said first and second portions of said cylinder defining a cylinder step in a wall of said cylinder;

a piston having a first portion and a second portion, said first portion having a first diameter which is smaller that a second diameter of said second portion, said first and second diameters of said first and second portions of said piston defining a piston step in an outer surface of said piston, said piston being disposed within said cylinder, said first and second portions of said cylinder being disposed in coaxial relation with each other along a first axis, said first and second portions of said piston being disposed in coaxial relation with each other along a second axis, said first and second axes being aligned with each other;

a compression chamber being bounded by said cylinder and piston steps, an outer surface of said first portion of said piston and an inner surface of said second portion of said cylinder;

a combustion chamber being bounded by an end of said first portion of said cylinder, an end of said first portion of said piston and a wall of said first portion of said cylinder;

a first conduit connected in fluid communication with said compression chamber;

a transfer passage formed in said piston, said transfer passage having a first end and a second end, said first end being disposed in fluid communication with said compression chamber, said second end being disposed in fluid communication with an opening in a surface of said first portion of said piston; and

a transfer port formed in a wall of said first portion of said cylinder, said transfer port providing fluid communication between said transfer passage and said combustion chamber when said opening is aligned with said transfer port.

14. The internal combustion engine of claim **13**, further comprising:

a first fuel supply device connected in fluid communication with said first conduit for providing a primary flow of fuel and air into said compression chamber.

15. The internal combustion engine of claim **14**, further comprising:

a crankcase;

a second conduit connected in fluid communication between said crankcase and said first portion of said cylinder.

16. The internal combustion engine of claim **15**, further comprising:

a second fuel supply device disposed in fluid communication with said crankcase for providing a secondary flow of fuel into said crankcase and into said compression chamber through said second conduit.

17. The internal combustion engine of claim **13**, further comprising:

an exhaust conduit connected in fluid communication with said first portion of said cylinder.

18. An internal combustion engine, comprising:

an engine block having a cylinder formed therein, said cylinder having a first portion and a second portion, said first portion having a first diameter which is smaller that a second diameter of said second portion, said first and second diameters of said first and second portions of said cylinder defining a cylinder step in a wall of said cylinder;

a piston having a first portion and a second portion, said first portion having a first diameter which is smaller that a second diameter of said second portion, said first and second diameters of said first and second portions of said piston defining a piston step in an outer surface of said piston, said piston being disposed within said cylinder, said first and second portions of said cylinder being disposed in coaxial relation with each other along a first axis, said first and second portions of said piston being disposed in coaxial relation with each other along a second axis, said first and second axes being aligned with each other;

a compression chamber being bounded by said cylinder and piston steps, an outer surface of said first portion of said piston and an inner surface of said second portion of said cylinder;

a combustion chamber being bounded by an end of said first portion of said cylinder, an end of said first portion of said piston and a wall of said first portion of said cylinder;

a first conduit connected in fluid communication with said compression chamber;

a transfer passage formed in said piston, said transfer passage having a first end and a second end, said first end being disposed in fluid communication with said compression chamber, said second end being disposed in fluid communication with an opening in a surface of said first portion of said piston;

a transfer port formed in a wall of said first portion of said cylinder, said transfer port providing fluid communication between said transfer passage and said combustion chamber when said opening is aligned with said transfer port;

a first fuel supply device connected in fluid communication with said first conduit for providing a primary flow of fuel and air into said compression chamber;

a crankcase; and

a second conduit connected in fluid communication between said crankcase and said first portion of said cylinder.

19. The internal combustion engine of claim **18**, further comprising:

a second fuel supply device disposed in fluid communication with said crankcase for providing a secondary flow of fuel into said crankcase and into said compression chamber through said second conduit.

20. The internal combustion engine of claim **18**, farther comprising:

an exhaust conduit connected in fluid communication with said first portion of said cylinder.

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